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THE

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AND

Journal of

The Mineralogical Society.

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THE MINERALOGICAL SOCIETY

MINERALOGICAL SOCIETY.

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MINERALOGICAL SOCIETY.

(*Instituted February* 3, 1876.)

BYE-LAWS.

1. The object of the Mineralogical Society of Great Britain and Ireland, with which the Crystallological Society was amalgamated on December 11, 1883, shall be to advance the knowledge of Mineralogy, and also of Crystallography and Petrology.

2. The Society shall consist of Ordinary Members and Honorary Members.

Ordinary Members.

3. Every candidate for Ordinary Membership shall be proposed by two Ordinary Members, one, at least, of whom shall have personal knowledge of the candidate.

4. Elections to Ordinary Membership shall be made by the Council, and shall be confirmed at the ensuing general meeting by a majority consisting of three-fourths of the Members present and voting.

5. Ordinary Members shall pay an entrance fee of one guinea and an annual subscription of one guinea. Ordinary Members elected on or before November 13, 1900, shall be entitled to compound for the annual subscription by a single payment of ten guineas: Ordinary Members elected after that date shall be entitled to compound for the annual subscription by a single payment of fifteen guineas.

6. Annual Subscriptions shall be due on the first of January of each year, but Members elected after the first of October shall not be required to pay a subscription for the then current year.

7. The name of any Ordinary Member whose subscription is more than two years in arrear shall be brought before the Council, and an intimation that this action has been taken shall be communicated to the Member. After the expiration of at least one year from that date, the Council shall be empowered to erase the name from the List of Members.

Honorary Members.

8. Twenty persons, non-resident in the United Kingdom, may be elected Honorary Members. They shall pay neither entrance fee nor annual subscription.

9. Every candidate for Honorary Membership shall be proposed by two Members of the Council, and the election shall be by the Council, and shall be confirmed at the ensuing general meeting by a majority consisting of three-fourths of the Members present and voting.

Council.

10. The Society shall be governed by a Council, consisting of a President, two Vice-Presidents, a General Secretary, a Foreign Secretary, a Treasurer, an Editor of the Journal, and twelve Ordinary Members.

11. All members of the Society who have served the office of President shall be life-members of the Council.

12. The Council shall be elected annually at the Anniversary Meeting.

13. Four Ordinary Members of Council shall retire annually, and shall not be eligible for re-election until the next Anniversary Meeting.

14. The Council shall prepare a List of Members nominated for election as Officers and Ordinary Members of Council.

15. The election of Council shall be effected by the agency of voting papers containing the List nominated by the Council. They shall be sent by the General Secretary, at least four weeks before the Anniversary Meeting, to every Ordinary Member of the Society, and every such Member shall be entitled to substitute the names of any other Ordinary Members of the Society for those on the List.

16. The voting papers shall be returned by the Members to the General Secretary, and shall be examined at the Anniversary Meeting by two Scrutineers appointed by the Chairman, who shall on their report declare the result of the election. The voting papers need not be signed.

17. The Council shall have power to appoint Officers, and to co-opt Ordinary Members of Council, to fill vacancies in the Council caused by death or resignation during the interval between two Anniversary Meetings.

18. Meetings of the Council shall be summoned by order of the President or the Council; at such meetings three shall be a quorum, of whom

one shall be either the President, a Vice-President, the Treasurer, or the General Secretary.

19. A Report of Council on the work and progress of the Society shall be submitted at each Anniversary Meeting.

Trustees.

20. Two or more Trustees shall be appointed by the Council, and the invested property of the Society shall stand in their names.

21. Composition-fees shall be treated as Capital: a Resolution of the Society at a general meeting, summoned with notice of a proposed disposition of property, shall be sufficient authority to the Trustees to give effect to such disposition; provided that a resolution of the Council shall be sufficient authority for any change of investment.

Meetings.

22. Meetings of the Society shall be summoned from time to time, as may be deemed necessary by the Council, or at the requisition of any ten Members of the Society. One of these meetings in each year shall be termed the Anniversary Meeting.

Journal.

23. The Numbers of the *Mineralogical Magazine and Journal of the Society* shall be issued at such intervals as the Council shall determine, and shall be sent, postage paid, to every Member of the Society.

Auditors and Balance Sheet.

24. Two Ordinary Members of the Society, one of whom is not a Member of the Council, shall be appointed annually by the Council to audit the accounts of the Society.

25. No auditor shall serve for more than three years in succession.

26. The audited Balance-Sheet, after submission to the Council, shall be published in the Journal of the Society as early as possible in every year.

Expulsion of Members.

27. A majority consisting of three-fourths of the whole Council shall have power to expel a Member from the Society, but a Member who has been expelled shall have a right of appeal to the Society. Notice of such appeal to the Society shall be sent by such Member to the General Secretary within four weeks of the expulsion, and the appeal shall be considered by the Society at the next Anniversary Meeting; a

majority of the votes recorded at such Meeting sufficing to confirm or annul the decision of the Council.

Alteration of the Bye-Laws.

28. The Bye-laws may be altered only at an Anniversary Meeting, and only by a majority consisting of three-fourths of the Members present and voting. Notice of changes proposed to be made in the Bye-laws shall be communicated by the General Secretary to every Ordinary Member of the Society at least four weeks before the Anniversary Meeting at which they are to be considered.

Obligation Book.

29. Ordinary Members, by payment of their entrance fee, signify their acceptance of any Bye-laws approved by the Society; and every Member of the Society shall sign an Obligation Book.

LIST OF MEMBERS.

(*September*, 1904.)

HONORARY MEMBERS.

M. E. Bertrand, *Paris.*
Dr. A. Brezina, *Vienna.*
Prof. W. C. Brögger, *Christiania.*
Prof. G. J. Brush, *New Haven, U.S.A.*
Prof. E. S. Dana, *New Haven, U.S.A.*
Prof. P. von Groth, *Munich.*
Prof. C. Klein, *Berlin.*
Prof. A. Lacroix, *Paris.*
Prof. V. von Lang, *Vienna.*
M. A. Michel Lévy, *Paris.*
Prof. T. Liebisch, *Göttingen.*
Prof. E. Ludwig, *Vienna.*
Prof. S. L. Penfield, *New Haven, U.S.A.*
Prof. H. Rosenbusch, *Heidelberg.*
Dr. K. J. V. Steenstrup, *Copenhagen.*
Prof. G. Strüver, *Rome.*
Prof. G. Tschermak, *Vienna.*
Prof. F. J. Wiik, *Helsingfors.*
Prof. F. Zirkel, *Leipzig.*

ORDINARY MEMBERS [1].

A. Annual Subscribers.

L. Life-Members.

C. Belonged to the Crystallological Society at the time of the amalgamation of the two Societies, December 11, 1883.

Year of Election.

L 1888 ARNOLD-BEMROSE, Henry Howe, M.A., F.G.S. *Ash Tree House, Osmaston Road, Derby.*

A 1881 BAKER, Harry, F.C.S. *Epworth House, Maughland Lane, Runcorn, Cheshire.*

L 1894 BARLOW, William, F.G.S., F.C.S. *The Red House, Stanmore, Middlesex.*

L 1876 BARNETT, A. K., F.G.S. 11 *Penrose Terrace, Penzance, Cornwall.*

L 1893 BARROW, George, F.G.S. Geological Survey of England. *The Museum, 28 Jermyn Street, London, S.W.*

L 1897 BEALE, William Phipson, K.C., F.G.S., F.C.S. 10 *New Court, Carey Street, London, W.C.*

A 1894 BERINGER, John J., A.R.S.M., F.C.S. *School of Mines, Camborne, Cornwall.*

A 1894 BERKELEY, The Rt. Hon. the Earl of, F.G.S., F.C.S. *Foxcombe, Boar's Hill, near Oxford.*

L 1876 BONNEY, Rev. Thomas George, D.Sc., LL.D., F.R.S. Emeritus Professor of Geology in University College, London. 23 *Denning Road, Hampstead, London, N.W.*

L 1897 BOWMAN, Herbert Lister, M.A., F.C.S. *Mineral Department, The Museum, Oxford.*

L 1876 BROWN, Alexander Crum, M.D., D.Sc., F.R.S. Professor of Chemistry in the University of Edinburgh. 8 *Belgrave Terrace, Edinburgh.*

A 1901 BURLS, Herbert Thomas, F.G.S. *Brunswick House, 84 Lee Road, Blackheath, London, S.E.*

L 1885 BUTLER, Francis Henry, M.A., A.R.S.M. 158 *Brompton Road, London, S.W.*

[1] Corrections for this List should be sent to the General Secretary, 35 Woodville Gardens, Ealing, London, W.

Year of Election.

A 1889 Butler, William Waters, F.C.S. *Southfield, Norfolk Road, Edgbaston, Birmingham.*

A 1903 Campbell, Donald Fraser, B.A., F.G.S. 36 *Oakley Crescent, Chelsea, London, S.W.*

A 1876 Church, Arthur Herbert, M.A., D.Sc., F.R.S. Professor of Chemistry in the Royal Academy of Arts. *Shelsley, Ennerdale Road, Kew, Surrey.*

A 1888 Cole, Grenville A. J., M.R.I.A., F.G.S. Professor of Geology in the *Royal College of Science, Dublin.*

L 1892 Collins, Henry F., A.R.S.M. 702 *Salisbury House, Finsbury Circus, London, E.C.*

L 1876 Collins, Joseph Henry, F.G.S. *Crinnis House, Par Station, Cornwall.*

L 1900 Coomáraswámy, Ananda K., B.Sc., F.L.S., F.G.S. Director of the Mineral Survey of Ceylon. *Kandy, Ceylon.*

L 1888 Crookes, Sir William, D.Sc., F.R.S. 7 *Kensington Park Gardens, London, W.*

A 1899 Cullis, Charles Gilbert, D.Sc., F.G.S. Assistant-Professor of Geology in the *Royal College of Science, South Kensington, London, S.W.*

L 1899 Currie, James, M.A., F.R.S.E. *Larkfield, Golden Acre, Edinburgh.*

L 1876 Danby, Thomas William, M.A., F.G.S. *The Crouch, Seaford, Sussex.*

L 1885 Daw, John W., 4 *Gunnersbury Avenue, Ealing, London, W.*

L 1898 De Castro, J. Paul, M.A., F.C.S., F.I.C. 1 *Arundel Street, Strand, London, W.C.*

L 1891 Evans, John William, LL.B., D.Sc., F.G.S. 75 *Craven Park Road, Willesden Junction, London, N.W.*

L 1900 Fleischmann, Friedrich Noel Ashcroft, M.A., F.C.S. 6 *Collingham Gardens, London, S.W.*

L C Fletcher, Lazarus, M.A., F.R.S. Keeper of Minerals in the British Museum (Natural History), Cromwell Road, London, S.W. 35 *Woodville Gardens, Ealing, London, W.*

L 1895 Fletcher, Rev. Mark, M.A., F.G.S. Demonstrator in Mineralogy in the Durham College of Science. *The Vicarage, North Sunderland, Chathill R.S.O., Northumberland.*

Year of Election.

A 1902 FLETT, John Smith, M.A., D.Sc., F.R.S.E., F.G.S. Geological Survey of England. *The Museum, 28 Jermyn Street, London, S.W.*

A 1876 GEIKIE, Sir Archibald, D.Sc., D.C.L., LL.D., F.R.S. Formerly Director-General of the Geological Surveys of the United Kingdom. 10 *Chester Terrace, Regent's Park, London, N.W.*

A 1876 GEIKIE, James, LL.D., D.C.L., F.R.S. Professor of Geology and Mineralogy in the University of Edinburgh. *Kilmorie, Colinton Road, Edinburgh.*

L 1881 GIBB, T. J., 37 *Old Jewry, London, E.C.*

L 1902 GILES, William B., F.I.C. *The Grange, Leyton, Essex.*

L 1886 GOLDSCHMIDT, Dr. Victor, Professor of Mineralogy in the University of Heidelberg. 9 *Gaisbergstrasse, Heidelberg, Germany.*

A 1895 GORDON, Rev. John More, F.G.S. *St. John's Vicarage, Redhill, Surrey.*

A 1903 GRABHAM, George Walter, B.A., F.G.S. Geological Survey of England. *The Museum, 28 Jermyn Street, London, S.W.*

L 1892 GREGORY, John Walter, D.Sc., F.R.S. Professor of Geology in the *University of Glasgow.*

A 1900 HALL, Arthur Lewis, B.A., F.G.S. *Geological Survey Office, Box 418, Pretoria, Transvaal.*

A 1885 HARKER, Alfred, M.A., F.R.S. Fellow of St. John's College, Cambridge. Geological Survey of Scotland. *St. John's College, Cambridge.*

L 1900 HARTLEY, Harold Brewer, B.A., F.C.S. *Balliol College, Oxford.*

A 1879 HENSON, Samuel, 97 *Regent Street, London, W.*

A 1888 HOFFMANN, G. Christian, LL.D. *Geological Survey Office, Sussex Street, Ottawa, Canada.*

L 1896 HOLLAND, Thomas Henry, A.R.C.S., F.R.S. Director of the Geological Survey of India. *Geological Survey Office, Calcutta, India.*

A 1879 HORNE, John, LL.D., F.R.S. Geological Survey of Scotland. *Geological Survey Office, Sheriff's Court Buildings, Edinburgh.*

Year of Election.

A 1902 Howe, John Allen, B.Sc., F.G.S. Curator of the Museum of Practical Geology. *The Museum, 28 Jermyn Street, London, S.W.*

A 1876 Hudleston, Wilfrid Hudleston, M.A., F.R.S. 8 *Stanhope Gardens, South Kensington, London, S.W.*

A 1878 Hughes, Thomas McKenny, M.A., F.R.S. Professor of Geology in the University of Cambridge. *Ravensworth, Brooklands Avenue, Cambridge.*

A 1893 Hussak, Dr. Eugen. *Commissão Geographica e Geologica de S. Paulo, Brazil.*

L 1890 Hutchinson, Arthur, M.A., Ph.D., F.C.S., F.G.S. Demonstrator of Mineralogy in the University of Cambridge. *Pembroke College, Cambridge.*

A 1899 Jackson, Henry, M.A., B.Sc., F.C.S. *Downing College, Cambridge.*

A 1902 Jevons, Herbert Stanley, M.A., D.Sc., F.G.S. Lecturer in Mineralogy and Petrology in the *University of Sydney, New South Wales.*

L 1884 Judd, John Wesley, C.B., LL.D., F.R.S. Professor of Geology in, and Dean of, the Royal College of Science, South Kensington, S.W. 22 *Cumberland Road, Kew, Surrey.*

L 1876 Kinch, Edward, F.C.S. Professor of Chemistry in the *Royal Agricultural College, Cirencester.*

L 1876 Kitto, Benedict, F.I.C., F.G.S. 26 *Lancaster Road, Finsbury Park, London, N.*

A 1885 Kunz, George Frederick, M.A., Ph.D. *Care of Messrs. Tiffany & Co., Union Square, New York City, U.S.A.*

A C Lewis, William James, M.A., F.C.S. Professor of Mineralogy in the University of Cambridge. *The New Museums, Cambridge.*

A 1886 Lindsey, C. R., B.Sc. 11 *Brantingham Road, Whalley Range, Manchester.*

I C Liveing, George Downing, M.A., D.Sc., F.R.S. Professor of Chemistry in the University of Cambridge. *Newnham, Cambridge.*

L 1876 Liversidge, Archibald, M.A., LL.D., F.R.S. Professor of Chemistry in the *University of Sydney, New South Wales.*

Year of Election.

A 1879 Louis, Henry, M.A., A.R.S.M., F.G.S. Professor of Mining in the *Durham College of Science, Newcastle-on-Tyne.*

A 1902 McGrigor, George Duncan, F.R.G.S. 25 *Charles Street, St. James's, London, S.W.*

A 1902 Maitland, Andrew Gibb, C.E., F.G.S. Government Geologist. *Geological Survey, Perth, Western Australia.*

L 1881 Mallet, Frederick Richard, F.G.S., F.C.S. 20 *King's Avenue, Ealing, London, W.*

A 1902 Mennell, Frederic Philip, F.G.S. Curator of the *Rhodesia Museum, Bulawayo, Rhodesia.*

L 1876 Merry, J. S., *Swansea, South Wales.*

L C Miers, Henry Alexander, M.A., D.Sc., F.R.S. Professor of Mineralogy in the University of Oxford. *Magdalen College, Oxford.*

L 1876 Morris, James, 6 *Windsor Street, Swansea, South Wales.*

A C Müller, Hugo, Ph.D., LL.D., F.R.S. 13 *Park Square East, Regent's Park, London, N.W.*

L 1880 Pearce, Richard, F.G.S. *Denver City, Colorado, U.S.A.*

L 1899 Pollard, William, M.A., D.Sc., F.G.S. Geological Survey of England. *The Museum,* 28 *Jermyn Street, London, S.W.*

A 1891 Pope, William Jackson, F.R.S. Professor of Chemistry in the Municipal School of Technology, Manchester. 16 *Hope Street, Higher Broughton, Manchester.*

A 1887 Pringle, A., M.A., B.Sc. Assistant Curator, Museum of Practical Geology. *The Museum,* 28 *Jermyn Street, London, S.W.*

L 1887 Prior, George Thurland, M.A., F.G.S. *British Museum (Natural History), Cromwell Road, London, S.W.*

A 1903 Rastall, Robert Heron, B.A., F.G.S *Christ's College, Cambridge.*

A 1876 Rudler, Frederick William, F.G.S. 18 *St. George's Road, Kilburn, London, N.W.*

A 1902 Russell, Arthur Edward Ian Montagu. *Swallowfield Park, Reading.*

L 1876 Scott, Robert Henry, M.A., D.Sc., F.R.S. 6 *Elm Park Gardens, London, S.W.*

A 1903 Scrivenor, John Brooke, M.A., F.G.S. Geologist to the Federated Malay States. *Kuala Lumpur, Federated Malay States.*

Year of Election.

A 1884 Seligmann, Gustav, 18 *Schlossrondel, Coblenz, Rhenish Prussia.*

L 1897 Smith, George Frederick Herbert, M.A., F.G.S., F.R.A.S. *British Museum (Natural History), Cromwell Road, London, S.W.*

A 1897 Sollas, William Johnson, M.A., D.Sc., LL.D., F.R.S. Professor of Geology in the University of Oxford. *The Museum, Oxford.*

A C Solly, Richard Harrison, M.A., F.G.S. *Downing College, Cambridge.*

L 1876 Sorby, Henry Clifton, LL.D., F.R.S. *Broomfield, Sheffield.*

A 1894 Spencer, Leonard James, M.A., F.G.S. *British Museum (Natural History), Cromwell Road, London, S.W.*

A 1878 Spezia, Giorgio, Professor of Mineralogy in the *University, Turin, Italy.*

A C Story-Maskelyne, Mervin Herbert Nevil, M.A., D.Sc., F.R.S. Late Professor of Mineralogy in the University of Oxford. *Basset Down House, Swindon, Wilts.*

A 1883 Teall, J. J. Harris, M.A., D.Sc., F.R.S. Director of the Geological Survey of the United Kingdom and of the Museum of Practical Geology. *The Museum, 28 Jermyn Street, London, S.W.*

A 1903 Thomas, Herbert Henry, B.A., F.G.S. Geological Survey of England. *The Museum, 28 Jermyn Street, London, S.W.*

L 1877 Trechmann, Charles O., J.P., Ph.D., F.G.S. *Hudworth Tower, Castle Eden, Co. Durham.*

A 1891 Tutton, Alfred Edwin Howard, D.Sc., A.R.C.S., F.R.S. 17 *Bardwell Road, Oxford.*

A 1876 Walker, John Francis, M.A., F.G.S., F.L.S., F.C.S. 45 *Bootham, York.*

L 1894 Watts, William Whitehead, M.A., F.R.S. Assistant Professor of Geology, University of Birmingham. *Holmwood, Bracebridge Road, Four Oaks, Sutton Coldfield, Warwickshire.*

L 1895 Webb, R. C.

I 1901 Weston, Digby, St. A. P., Lieutenant R.N., *H.M.S. Albion, China Station.*

I 1876 Wills, J. Lainson, F.C.S. *Care of Dr. F. Wyatt, 39 South William Street, New York City, U.S.A.*

Year of Election.

L 1896 WILLS, Louis.

A 1889 WOODWARD, Bernard Henry, F.G.S. *The Museum, Perth, Western Australia.*

L C WOODWARD, Charles J., B.Sc., F.G.S. Birmingham Municipal Technical School. 127 *Metchley Lane, Harborne, Birmingham.*

A 1897 WOOLLETT, N. E.

A 1902 YOUNG, Alfred Prentice, Ph.D., F.G.S. *Care of Messrs. Grindlay & Co., 55 Parliament Street, London, S.W.*

PROCEEDINGS

OF THE

MINERALOGICAL SOCIETY.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, November 17, 1903.

Dr. Hugo Müller, F.R.S., President, in the Chair.

The following Candidates were elected Ordinary Members of the Society:—Mr. Donald Fraser Campbell, B.A.; Mr. George Walter Grabham, B.A.; and Mr. Robert Heron Rastall, B.A.

The death of Professor A. F. Renard, Honorary Member of the Society, was announced, and the Foreign Secretary was requested to send a letter of condolence to the widow.

The following were selected as dates of meeting for 1904:—February 2, March 22, June 7, November 15, the last to be the Anniversary Meeting.

The draft Annual Report of Council, submitted by the Secretary, was read and approved.

ANNIVERSARY MEETING.

Held in the Apartments of the Geological Society, November 17, 1903.

Dr. Hugo Müller, F.R.S., President, in the Chair.

Twenty-three Members were present.

The scrutineers reported that thirty-nine voting papers had been returned to the General Secretary, and that the List as nominated by the Council was approved, namely:—

President. Hugo Müller, Esq., Ph.D., LL.D., F.R.S.

Vice-Presidents. Prof. G. D. Liveing, M.A., D.Sc., F.R.S.
Prof. H. A. Miers, M.A., D.Sc., F.R.S.

Treasurer. W. Phipson Beale, Esq., K.C., F.G.S., F.C.S.

General Secretary. L. Fletcher, Esq., M.A., F.R.S.

Foreign Secretary. Prof. J. W. Judd, C.B., LL.D., F.R.S.

Editor of the Journal. L. J. Spencer, Esq., M.A., F.G.S.

Ordinary Members of Council.

W. Barlow, Esq., F.G.S., F.C.S.
B. Kitto, Esq., F.I.C., F.G.S.
F. W. Rudler, Esq., F.G.S.
G. F. Herbert Smith, Esq., M.A., F.G.S.
A. Harker, Esq., M.A., F.R.S.
Lieut.-Gen. C. A. McMahon, F.R.S.
W. Pollard, Esq., M.A., D.Sc., F.G.S.
G. T. Prior, Esq., M.A., F.G.S.
H. L. Bowman, Esq., M.A., F.C.S.
H. F. Collins, Esq., A.R.S.M.
C. G. Cullis, Esq., D.Sc., F.G.S.
R. H. Solly, Esq., M.A., F.G.S.

The following Annual Report of Council was read:—

The Balance Sheet for the year ending December 31, 1902, shows that the Assets of the Society (exclusive of the Library and the Stock of the Journal) amounted to £623 10*s.* 7*d.*, and that the Liabilities amounted to £18 11*s.* 3*d.* The number of Life-Members on December 31, 1902, was fifty-two; the value of the Stock invested in the names of the Trustees of the Society was on that date £508 7*s.* 6*d.*

During the Session 1902–3 the Society has lost by death two Ordinary and two Honorary Members; on the other hand, eight Ordinary Members have been elected, and Professor Liebisch, of Göttingen, and Professor G. Strüver, of Rome, have been added to the list of Honorary Members. The total number of Members is now 126; of these 107 are Ordinary Members and nineteen are Honorary Members.

Four meetings have been held during the year, all in London and (by kind permission) in the Apartments of the Geological Society, Burlington House.

One Number of the Journal, No. 61, published in February, 1903, has appeared during the Session.

The Council has to congratulate the Society on its continued prosperity.

On the motion of Professor H. A. Miers, seconded by Mr. H. L. Bowman, the Report was adopted. A vote of thanks to the Geological Society for the permission to meet in its Apartments was carried with acclamation.

The elections of Mr. D. F. Campbell, Mr. G. W. Grabham, and Mr. R. H. Rastall to the Ordinary Membership of the Society were confirmed.

The following papers were then read:—

1. On Sartorite, Anatase, Galena, and other minerals from the Binnenthal: by Mr. R. H. Solly (p. 16).

2. On the pleochroism of Adamite: by Mr. L. J. Spencer.

3. On the prismatic method of determining refractive indices: by Mr. G. F. Herbert Smith.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, February 2, 1904.

Dr. Hugo Müller, F.R.S., President, in the Chair

The resignation of Mr. S. R. Adcock was accepted.

Mr. J. H. Collins and Mr. H. L. Bowman were appointed to audit the accounts of the Society.

Professor S. L. Penfield, of Yale University, was elected an Honorary Member.

GENERAL MEETING.

Held in the Apartments of the Geological Society, February 2, 1904.

Dr. Hugo Müller, F.R.S., President, in the Chair.

Twenty-two Members and three Visitors were present.

The election of Professor S. L. Penfield, Yale University, to the Honorary Membership was confirmed.

The following papers were read:—

1. The Gnomonic Net: by Mr. Harold Hilton (p. 18).

2. On a new sulphostannite of lead (Teallite), from Bolivia, and its relations to Franckeite and Cylindrite: by Mr. G. T. Prior (p. 21).

Mr. W. F. Ferrier then gave a short account of the discovery of Corundum in Canada and its mode of occurrence in that region.

Professor H. A. Miers, followed by Mr. W. F. Ferrier, Mr. L. J. Spencer, and Mr. J. H. Collins, called the attention of the members to the exhibition of the Rashleigh Mineral Collection in the Truro Museum, specially mentioning the Connellite, Cassiterite, Clinoclase, and Erubescite.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, March 22, 1904.

Dr. R. H. Scott, F.R.S., Past-President, in the Chair.

The Secretary announced the deaths of Professor Ferdinand Fouqué, Honorary Member, and Lieut.-Gen. C. A. McMahon, Ordinary Member.

The audited Balance Sheet for the year ending December 31, 1903, was submitted and approved.

It was reported that Mr. L. J. Spencer had sent in to the Central Bureau of the International Catalogue of Scientific Literature 535 slips relative to titles of mineralogical papers published in Great Britain during 1903.

GENERAL MEETING.

Held in the Apartments of the Geological Society, March 22, 1904.

Professor H. A. Miers, F.R.S., Vice-President, in the Chair.

Nineteen Members were present.

The following papers were read:—

1. Irregularly developed crystals of Zircon (specific gravity 4·0) from Ceylon: by Mr. L. J. Spencer (p. 43).

2. Notes on 'Feather-ore': identity of 'Domingite' (= 'Warrenite') with Jamesonite: by Mr. L. J. Spencer.

3. Further determinations of the indices of refraction of Stibnite from Japan: by Dr. A. Hutchinson.

4. The connexion between the atom-arrangements of the crystals of certain allied carbon compounds: by Mr. W. Barlow.

5. On the construction and use of a diagram in connexion with the anharmonic ratios of four tautozonal planes: by Mr. Herbert Smith (p. 49).

6. Note relative to the history of the Caperr meteorite: by Mr. L. Fletcher (p. 41).

7. On the meteoric irons of Bethany, Lion River, Mukerop, Springbok River, and Great Fish River, South Africa: by Mr. L. Fletcher (pp. 28, 37).

Further Professor Judd called attention to two twins of Quartz from La Gardette, which he submitted for inspection.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, June 7, 1904.

Dr. Hugo Müller, F.R.S., President, in the Chair.

The Secretary announced the deaths of Professor Sir Clement Le Neve Foster, Mr. Frank Rutley, and Mr. Hamilton Charles Dickson, and the resignation of Mr. William Rich, Ordinary Members of the Society.

Resolved to nominate as Officers and Council for the Session 1904–5, the following :—

President. Professor H. A. Miers (*vice* Dr. Hugo Müller).

Vice-President. Professor W. J. Lewis (*vice* Professor H. A. Miers); and Dr. J. W. Evans, the Rev. J. More Gordon, Mr. J. Allen Howe, and Dr. A. Hutchinson in place of Messrs. Barlow, Kitto, Rudler, and McMahon, Ordinary Members of Council; the remainder of the Officers and Council to be the same as at present.

GENERAL MEETING.

Held in the Apartments of the Geological Society, June 7, 1904.

Dr. Hugo Müller, F.R.S., President, in the Chair.

Sixteen Members and two Visitors were present.

A photogravure of the portrait of Professor Groth was submitted for inspection (p. 66).

The following papers were read :—

1. On cobaltiferous Mispickel from Norway: by the Rev. Mark Fletcher (p. 54).

2. On an improved form of Refractometer: by G. F. Herbert Smith.

3. Notes on the Development of the Kimberley Diamond Mines: by Professor H. A. Miers.

Professor Miers' notes were accompanied with numerous lantern illustrations.

MINERALOGICAL SOCIETY.

ABSTRACT OF RECEIPTS AND PAYMENTS FROM JANUARY 1 TO DECEMBER 31, 1903.

Receipts.	£ s. d.	£ s. d.
Balance from 1902		90 15 0
Subscriptions—(1) current	40 19 0	
(2) arrears	9 9 0	
(3) in advance	3 3 0	
		53 11 0
Entrance fees and compositions		22 1 0
Sales of publications by publishers (1902)	11 11 6	
Do. by G. Savigar (1902)	1 5 7	
		12 17 1
Dividends on Stock		14 12 5
Donation towards Illustrations		5 13 6
Overpayment of foreign subscriptions		0 2 0
		£199 12 0

Payments.	£ s. d.	£ s. d.
Printing Magazine (No. 61)	35 5 10	
Authors' separate copies	5 11 9	
Illustrations (Printers)	10 16 6	
„ (Miss Drake)	2 2 0	
		53 16 1
Miscellaneous Printing		8 8 7
Editor's Honorarium (1902)		10 10 0
Postage and Parcels		2 3 10
G. Savigar for care of stock (1902)		1 1 0
Porter's Fee		1 0 0
Bank Charges		6 0
Investments		67 2 5
Balance at Bank	50 16 5	
„ in Office	4 7 8	
		55 4 1
		199 12 0

Examined and compared with the vouchers, and found correct.

(*Signed*) J. H. COLLINS. H. L. BOWMAN. } Auditors.

Liabilities.	£ s. d.
Owing for Printing, &c., of No. 62 of Magazine	51 7 1
„ Editor's Honorarium (1903)	10 10 0
„ Miscellaneous Printing	4 14 10
„ G. Savigar for care of Stock (1903)	1 1 0
„ Do. for postage	0 1 4
„ Secretary's postage (1903)	0 17 8
„ Treasurer's „ (1903)	0 8 10
Excess of assets over liabilities	556 9 9
	£625 10 6

Assets.	£ s. d.
Balance at Bank	50 16 5
„ in Office	4 7 8
Consols (£629 6s. 1d., valued at £87)	547 9 10
Balance owing from Publishers	12 16 0
„ „ „ G. Savigar	0 11 7
Subscriptions in arrear, valued at	9 9 0
	£625 10 6

The number of Life-Members on December 31, 1903, was 52.

The Stock of Publications and the value of the Library are not included in the above assets.

(*Signed*) W. P. BEALE,

THE MINERALOGICAL MAGAZINE

AND

JOURNAL OF

THE MINERALOGICAL SOCIETY.

No. 63. October, 1904. Vol. XIV.

An improved form of Three-Circle Goniometer.

(*With Plate I.*)

By G. F. Herbert Smith, M.A., F.G.S.

Assistant in the Mineral Department of the British Museum.

[Read June 10, 1902.]

In a previous paper[1] the author pointed out the advantages of a goniometer possessing three graduated circles, and described an instrument of this type which had resulted from the addition of a two-circle arrangement to an ordinary reflective goniometer with a single (horizontal) circle. As was remarked in that paper, the adapted instrument has unavoidably the disadvantage that measurements can be made through little more than a right angle in any particular zone, with the single exception of the zone of reference, without readjustment of the vertical and third circles. The zone may, indeed, be completed by measuring from the diametrically opposite pole in the zone of reference; but difficulties occasionally arise in practice, and it is convenient to be able to measure through at least two right angles round the free end of the crystal by rotation of the horizontal circle only. In a subsequent note[2] the author suggested a way of overcoming this difficulty; and in fulfilment of the hope therein expressed he describes in the present paper an instrument, in the construction of which the

[1] 'A three-circle goniometer,' Min. Mag., 1899, vol. xii, pp. 175–182; a translation appeared in Zeits. Kryst. Min., 1900, vol. xxxii, pp. 209–216.

[2] 'Preliminary note on an improved form of three-circle goniometer,' Min. Mag., 1901, vol. xiii, pp. 75–76.

suggested improvements with some modifications have been incorporated. The instrument has been constructed for the British Museum by Messrs. Troughton & Simms, of London.

As regards the arrangement of the graduated circles there is in principle no change at all, and the alterations relate solely to the optical parts of the instrument. The *line of reference*, i.e., the line to which the face under observation is brought perpendicular, is reflected so as to be nearly at right angles to the ordinary position. Thus on rotation round the axis of the horizontal circle the axis of the vertical circle may coincide with the line of reference in two positions, and observations may be obtained of both the faces of the crystal which are at right angles to this axis; previously no observation was possible from the face next to the vertical circle.

In order to effect this change, an auto-collimating telescope was at first employed, and the direction of light bent by means of a reflecting prism placed before the object-glass. This arrangement, however, was found in practice to introduce several difficulties: the stray light reflected from the back of the object-glass caused a glare in the field of view which completely prevented observation of minute crystalline faces; further, accompanying the principal image of the object-slit were to be seen a series of 'ghosts,' i. e., the images due to multiple reflections at the crystal-face and the near face of the prism; lastly, the field of view of the telescope was not as large as is desirable. These difficulties were, indeed, to some extent overcome; but after some trial it was finally decided to use separate tubes for the telescope and collimator, lying alongside each other, and to replace the single glass-prism by two distinct mirrors, one for each tube. The use of separate reflectors secured greater facility of adjustment.

(*a*) *The principle of a goniometer with three graduated circles.*

The object of a three-circle goniometer is to bring any desired edge on the crystal without readjustment parallel to some arbitrary direction in space, and it may be effected in various ways: but undoubtedly in practice the most convenient method is to maintain the optical parts, and therefore the eye of the observer, in the same position and to assign all the motions to the part carrying the crystal. The crystals usually selected for measurement are small, and, their weight being inconsiderable, they are held rigidly by the wax during the course of the observations. In the case of a goniometer constructed for the measurement of large crystals and especially of crystals still in position on the matrix, it

would be advisable to give two of the motions to the optical parts. In such an instrument the specimen would be rotated about an horizontal axis only, and the bearing cones of the axis would be relieved of unnecessary strain by means of a counterbalancing spring placed underneath the stage.

In the present instrument all the motions have been given to the crystal, and the goniometer possesses essentially three graduated circles arranged thus:—

A the horizontal circle, whose axis is vertical and fixed in space;

B the vertical circle, whose axis is movable in an horizontal plane; and

C the third circle, whose axis may assume any desired direction in space.

These circles must satisfy the following conditions:—

The axis of *A* must be at right angles to the line of reference;

The axis of *B* must be at right angles to that of *A*;

The axis of *C* must be at right angles to that of *B*, although inclinable at any angle to that of *A*; and finally

All three axes must pass through the same point, the *optical centre*, which must itself lie on the line of reference.

How these conditions may be fulfilled will be considered after the description of the instrument.

(*b*) *The construction of the instrument.*

The base of the goniometer is formed of a tripod resting on three levelling screws. Rigidly connected with it are the arms carrying the pair of microscopes used for reading the scale of the circle *A* and the pillar supporting the tubes of the telescope and collimator. The latter tubes lie within outer tubes, each of which is adjustable about a vertical axis and about an horizontal axis at right angles to the length of the corresponding tube by means of three screws, one pushing and two pulling, which operate on the fixed collar. The tubes themselves may revolve about, and be translated in the direction of, their length; they are held by means of tangent screws which grip the split ends of the outer tubes. A small reflecting prism is placed immediately outside the slit of the collimator to permit of illumination from the side.

At the ends of the telescope and collimator remote from the observer are two tubes carrying mirrors, which fit round, and may slide along, the optical tubes; the ends away from the mirrors are split and the two halves are fitted with tangent screws to permit of rigid clamping to the

corresponding optical tubes. Each mirror has three adjustments: a revolution about the length of the tube containing it, a translation in this direction, and finally a small adjustment about a vertical hinge; the last movement being actuated by means of a screw working against a spring. The telescope-mirror is placed further away than the collimator-mirror, and its tube is cut away at the sides so as to permit the passage of light reflected from the latter mirror. The mirrors are composed of speculum-metal, which gives reflections comparable in brightness with those obtained from totally-reflecting glass-prisms and avoids the difficulty due to stray reflections or 'ghosts.' If the metal becomes tarnished, it is easily cleaned by means of cotton-wool dipped in a mixture of two parts of alcohol and one part of ammonia; methylated spirit is not suitable because of the film frequently left on evaporation.

The Signal.

On the top of the tube containing the telescope-mirror is a recess, which receives an achromatic lens when not in use. The lens is hinged about an horizontal axis, and a lever without the tube enables the observer to place it in front of the object-glass of the telescope, thus converting the latter into a microscope of low power for viewing the crystal under measurement. Another lens is carried on an arm, which is hinged on a slide movable along a bar placed on the top of the telescope-tube near the eyepiece, and may be placed in front of the eyepiece; in this way smaller magnification is obtained, and the crystal is visible when not accurately placed at the optical centre.

The cross-wires in the telescope are fixed in position. Three eyepieces of varying powers are provided for viewing the reflected image. The type of signal employed (see fig.) differs slightly from that in ordinary use, because the image has to be accurately placed with respect to the horizontal as well as with respect to the vertical wire. The width may be altered at will; but once set it should not be altered, since the zero-reading of the circle A is affected at the same time.

The circle A has a diameter of 18 cm., approximately, and rotates about a vertical axis. Underneath its stage is a countervailing spring, by means of which the bearing surfaces of the cones may be relieved of as much of the superincumbent weight as may be desired. Inside the plate, on the bevelled edge of which the circle A is graduated, is another cone, larger in diameter but shorter in length, which is rigidly connected with the thick plate which carries the remaining circles and

their accessories. The latter portion of the instrument may thus be rotated independently of A and placed in any position at will with respect to it; a strong clamp is provided for holding the two plates firmly together when in their proper relative position. By means of this device, as will be explained below (p. 11), the zero-readings of A may be made very nearly 360° and 180°. The scale is divided to 10′ and is read by means of a pair of microscopes placed diametrically opposite each other. In the focal plane of each is a pair of spider-lines, whose distance apart is equal to the apparent width of the divisions on the scale; they are operated by a micrometer-screw. One revolution of the screw carries the spider-lines from one to the next division on the scale, and thus corresponds to an angle of 10′. Its head is divided into ten parts, each of which is subdivided into six intervals, which therefore correspond to tens of seconds; hence by estimation the circle may be read to single seconds of arc.

The arm carrying the circle B is firmly attached to the plate mentioned above, by means of four screws, on releasing which the whole piece may be adjusted by means of other screws either towards the axis of A or at right angles to this direction. The fixed limb, carrying a pair of microscopes for reading the scale of B, is attached to the arm by means of three adjusting screws. Each pair consists of a larger screw of low pitch operating on the arm, and of a smaller screw, passing through the former and holding the microscope-limb firmly against the blunt points of the larger screw. The adjustment is made by moving the larger screws through the desired amount; the smaller screws are then tightened. By this device the pull on the limb is direct and there is no tendency to twist. Both sets of screws have hexagonal heads and are turned by means of the spanners shown at the base of the instrument (Plate I). The scale is 11 cm., approximately, in diameter, and is read in the same way as that of A by means of a pair of microscopes to 10″ directly, and to single seconds of arc by estimation.

To prevent excessive wear of the lower half of the fixed cone of the circle B owing to the weight bearing on it, two pairs of friction wheels are provided: one pair lies on the fixed limb between it and the circle, and is operated by means of a single balanced spring, to assure the pressure being always vertical; the other pair, visible in the picture, lies near the counterpoise and is operated by an adjustable spring. By means of pins passing through the fixed limb the former pair may be held out of the way, whilst the circle B is being placed in position, after removal for the cleaning of the bearings or some other purpose. The pin,

on which the spring of this pair is pivoted, projects through the fixed limb, and may be raised, if it is found desirable to increase the counter-vailing pressure on the movable cone.

The arm, carrying the circle C, and the inside cone of the circle B are formed of a single casting to ensure the greatest possible rigidity. The latter circle is firmly attached to the arm, and the relative positions of the circle and the arm cannot, therefore, be altered, as is the case with the horizontal circle and the corresponding plate, for the purpose of making the zero-reading of the scale of B some convenient quantity. It has, however, been arranged that this reading should be approximately 180°, or 360° (depending on the microscope used), and it can be made almost exactly so by moving the microscopes; for this purpose the holes, through which pass the screws holding the microscopes to the fixed limb of the circle B, have been slotted.

The circle C is read to minutes of arc by means of a pair of oppositely placed verniers; greater refinement is unnecessary because more exact measurements may be made by means of the circle A. The fixed limb, carrying the verniers, is attached to the arm by means of three pairs of adjusting screws as before. Its scale has a diameter of 9 cm., approximately, and the cones taper towards the crystal-holder, since this is the usual tendency of the weight.

All three circles have the ordinary type of clamp and slow motion. The crystal-holder too is of the usual form, and possesses all the adjustments required. The rods, on which the crystals to be measured are fixed, are grooved down their length, so that any rod may be removed from the goniometer and set up again in very nearly the same position.

Counterpoises are provided to maintain the pressures evenly on the bearing cones of the circles A and B; that balancing the third circle C and the crystal-holder has been placed on the other side of the circle B, any shear on the cones of the circle B being thus obviated.

The mirrored axes of the telescope and collimator are inclined to each other at an angle of 22°, approximately. The greatest possible rotation about the axis of A is 240°, approximately; the axis of B can make with the line of reference angles of 57° towards the telescope and 3° towards the collimator respectively. When B is next to the collimator and its axis coincides with the line of reference, the greatest rotation about its axis is 188°, approximately, the axis of C making with the vertical, angles of 53° and 135° towards the collimator and the circle A respectively; when B is on the other side, the greatest rotation is 200°, approximately, the axis of C making the same angle towards the circle

A, but an angle of 65° towards the telescope. The last angle might with advantage be made at least 90°, which, indeed, was the original arrangement before the alteration of the optical parts, by placing the tubes of the telescope and collimator closer together.

The tripod, main stage, and the circles are constructed of gun-metal; for the arm carrying the circle *C* and for the microscope-arms phosphor-bronze has been used; and the central rod of the crystal-holder is made of steel.

(*c*) *The adjustments.*

We may now consider the method of effecting the necessary adjustments.

To adjust the line of reference perpendicular to the axis of *A*, it is convenient, though in this type alone of goniometers not necessary, to use a plate of glass, the sides of which are accurately parallel. Such plates are supplied with goniometers by the makers and are as a rule correct enough for the purpose; nevertheless this has always been the weak point of the adjustments of such instruments, because the parallelism of the plate has to be assumed and is beyond the control of the observer.

Although not essential, it is convenient to have the mirrored axes of the telescope and collimator, and not merely the line of reference which bisects their acute angle, at right angles to the axis of *A*. The adjustment is effected in the usual way. The parallel-sided glass-plate is mounted on the crystal-holder, and adjusted as accurately as the eye can judge so that its plane is parallel to the axis of *A*. Care must be taken that the circle *B* is in such a position that a semi-revolution about the axis of *A* is possible. A glass-plate, the sides of which need not be parallel or even plane—a microscope-slide serves the purpose well enough—since no serious error is thereby introduced, is held in such a position in front of the eyepiece that light from the source of illumination is reflected down the tube of the telescope; the object being to illuminate the cross-wires and thus to see their images derived by reflection from the glass-plate. The images are not at first easily seen because of the confusion caused by the brilliant images of the source of illumination obtained by reflection from the surfaces of the various lenses in the telescope; and it is, therefore, convenient to use for the first rough adjustment the image of this source obtained by reflection from the plate; it is easily distinguished from the other images by being fainter and by moving with the plate. This image serves as a useful

indicator for the images of the cross-wires, which may be seen after a little manipulation of the plate reflecting light down the tube. It may be remarked that, unless the cross-wires are set accurately in the focal plane of the telescope, their image thus derived will not come to focus in the same plane, and may, indeed, not be visible at all; this affords a test of the accuracy of the focusing of the telescope. The tube of the telescope-mirror is adjusted until the cross-wires and their images coincide. Rotating the plate through a semi-revolution about the axis of A, we view the images obtained by reflection from the other side of the plate: whatever be the interval separating the horizontal wire from its image, the plate must be adjusted through one half and the telescope-mirror through the other half. Turning back to the other side of the glass-plate, we repeat the adjustment. The agreement is soon made satisfactory.

The next step is to adjust the mirror of the collimator until the image of the signal, when in the centre of the field, is bisected by the horizontal wire. It may happen that on rotation about the axis of A the centre of the image does not traverse the horizontal wire, or in other words the mirrored wire is not perpendicular to this axis: we must rotate the tube of the telescope and at the same time the mirror-tube through the same angle in the opposite sense until the adjustment is effected. A similar adjustment must be made in the case of the collimator, should the image not be upright.

To adjust the axis of B perpendicular to that of A, we retain the glass-plate in the same position as before, and rotate it about the axis of C, until it is roughly at right angles to that of B: then we clamp C. By means of the crystal-adjustments and the slow-motion of C we set the plate in such a position that on rotation about the axis of B there is no movement of the image of the signal. For this adjustment we require at least a semi-revolution about the axis of B. We now adjust the axis of B with respect to that of A by means of the screws provided for the purpose until the image is exactly bisected by the horizontal wire.

The axis of C may be adjusted perpendicular to that of B in precisely the same way: the axis of B is rotated about that of A until it makes a right angle with its former position, and a side of the plate is brought exactly perpendicular to the axis of C, so that there is no movement of the image obtained by reflection from it. The axis of C is now adjusted until the image is bisected by the vertical wire; if at the same time it is bisected by the horizontal wire, the reading of B gives us the horizontal position of the axis of C. An equally effective and, since we

may retain the glass-plate in its initial position, more convenient method is to make the axis of C coincide with that of A. Then since the latter is perpendicular to that of B, so must the former be. Keeping the axis of B in coincidence with the line of reference, we rotate the glass-plate about the axis of C. The images from the two sides will probably not both be bisected by the horizontal wire. By means of the crystal-adjustment make one lie as far above as the other is below; then by means of the adjustment of C adjust the axis until one image, and concurrently the other, is symmetrically set with respect to the horizontal wire. Rotating round the axis of A through a right angle and finding the reading of B when the image is set on the same wire, we obtain the zero-reading of B, i. e., the reading corresponding to the vertical position of the axis of C. The great advantage of this method is that it enables the observer to check any adjustment of direction without altering the position of the glass-plate.

In the final adjustment, the parallelism of the glass-plate may be disregarded. As has been pointed out earlier in this paper (p. 2), the axis of B may be parallel to the line of reference, or, if correct in absolute position, may coincide with it, in two positions, the circle B lying first on one, and then on the other, side of the optical parts. In either position we may adjust accurately some plane surface, say a side of the glass-plate hitherto employed, perpendicular to the axis of this circle. It is clear then that, if the images in the two cases have been symmetrically set on the cross-wires, the corresponding planes have occupied exactly parallel positions. We now adjust the axis of B with respect to that of A until the two images are bisected by the horizontal wire.

To adjust the axis of C, we turn from one position to the other through a semi-revolution about the axis of A, and then rotate C also through a semi-revolution, so that the image obtained by reflection from the same side of the glass-plate as before is on the cross-wires: whatever be the interval separating the centre of the image from the horizontal wire, we adjust the plate through one half and the axis of C with respect to that of B through the other half. The accuracy of the adjustment is tested again in the initial position. Turning round the axis of A until that of B is at right angles to the line of reference, we rotate the glass-plate about the axes of B and C until the image is set symmetrically on the cross-wires. The axes of A and C, if correct in absolute position, now coincide; and if, clamping B in this position, we rotate about these axes so as to retain the image in the field of view, it should always be bisected by the horizontal wire.

The axes of the three circles are now accurately placed as regards direction; and it only remains to adjust them in absolute position so that they pass through the same point, the optical centre, which must itself lie on the line of reference.

The glass-plate is replaced by a rod, sharpened to a point at the free end, and the telescope is converted into a microscope by means of the auxiliary lens which is placed before the object-glass. The point is raised or lowered until it is somewhere near the centre of the field, and adjusted until there is no shift on rotation about the axis of *A*. Should the point not lie on the vertical wire, the telescope must be adjusted accordingly by translation in the direction of its length; the final adjustment should be made by turning the mirror about its vertical hinge. Since it is impossible to make this translation without affecting the position of the line of reference, the needle-point should be brought beforehand just on to the horizontal wire, and after adjustment has been made, the point should be again set on the wire; with this precaution the readjustment of the line of reference required will be small.

We next raise or lower the needle-point until there is no shift on rotation about the axis of *B*. If the point now lies off the horizontal wire, we turn the collar containing the telescope-tube about its horizontal axis accordingly. If, when the axis of *B* is parallel to the line of reference, the point lies off the vertical wire, we release the screws holding the base of the arm carrying the circle *B*, and move its axis parallel to itself horizontally by means of the screws provided until the point is exactly on the vertical wire after the clamping screws of the base have been securely tightened; this adjustment may, if preferred, be effected by means of the two double-screws lying in an horizontal plane, which hold the fixed limb carrying the pair of microscopes firmly to the arm just mentioned.

The final step is to adjust the needle-point until there is no shift on rotation about the axis of *C*. If, on turning round the axis of *A* until that of *B* is at right angles to the mirrored axis of the telescope, we find that the point lies off the vertical wire, we again release the screws holding the base, and move the arm to or from the axis of *A* as may be required. If, again, when the axis of *B* is parallel to the mirrored axis of the telescope, the point lies off the vertical wire, we adjust the axis of *C* accordingly so that it moves towards that of *B*.

We have only to adjust the collimator in absolute position so that its mirrored axis passes through the optical centre. To do this, we adjust the glass-plate so that the image obtained by reflection from it lies sym-

metrically on the cross-wires, and, removing the eye-piece, we glance down the tube of the telescope. A portion of a circular patch of light is seen, due to the reflection of the illuminated object-glass of the collimator. If we adjust the collimator until this patch lies symmetrically with regard to the object-glass of the telescope, we shall effect the adjustment with sufficient accuracy for the purpose.

We must make a final test of all the adjustments, and the goniometer is ready for use.

For convenience of discussion, the various adjustments have been taken in the above order; but in actual practice we should make the absolute adjustment immediately after the corresponding relative adjustment, and thus, as far as possible, avoid interference with adjustments already made.

(*d*) *The method of using the instrument.*

We must first determine the exact zero-readings of the circles *A* and *B*. It was pointed out above (p. 5) that the upper part of the instrument could be rotated about an interior cone independently of the circle *A*. Rotating, then, *A* until the microscope next the observer reads exactly 360°, we turn the upper part until the axis of *B* coincides with the line of reference and the circle *B* lies on the side of the crystal-holder remote from the optical parts and clamp the parts together. Whatever correction may now be found necessary will only be a few seconds. Next we find the position in which the axis of *C* is vertical, and move the microscopes provided for reading the scale of *B* until they read as nearly as possible 360° and 180° respectively. A small correction may be found necessary, but it will only amount to a few seconds.

To make the best use of the goniometer, we adjust the edge of some prominent zone, preferably one of symmetry, parallel to the axis of *C*. To effect this, the axis of *B* is brought into coincidence with the line of reference; at the same time the axis of *C* should be vertical, since in that position the images obtained by reflection from the faces of the zone, when in adjustment, will cross the field horizontally on rotation of this axis, and the adjustment is made with greater facility. The zone thus adjusted is termed the *zone of reference*. We rotate *C* and take the readings of this circle for every face in the zone of reference, the axis of *B* still coinciding with the line of reference. Each reading corresponds to the position in which the particular face is perpendicular to the axis of *B*, and hence on rotation about this axis that face always remains

parallel to the same plane. The faces in the zone of reference may conveniently be termed *origins*. The readings of the circles A and B for any other face of the crystal give us, after any correction required has been made, the distance and azimuth measured from the origin and the zone of reference, respectively. If the zone under measurement does not intersect the zone of reference in an existing face, the reading of C, taken in conjunction with the readings already found for the origins which have been encountered, will give the position of the pole of intersection in the zone of reference. The circle C can be read to minutes only; more exact measurements may be made on the circle A, if the axis of C be maintained in the vertical position.

Having measured the zone of reference, we study the observations and note the symmetry possessed by the zone. From a face of symmetry, if there be one, as origin, we systematically measure the crystal, commencing with the zone of reference and gradually increasing the azimuthal angle. A few measurements will soon show what symmetry the crystal apparently possesses. If the zone initially selected for reference is not a principal zone on the crystal, it is best to readjust the crystal so as to make such a zone that of reference.

Having completed the measurement of the crystal, we plot the positions of the poles of the observed faces on a sheet of paper. Whether the stereographic or gnomonic projection be selected, the plane of the diagram should be at right angles to the edge of the zone of reference. In general work the former projection is the more suitable. The author has found the stereographic net [1] devised by Professor E. von Fedorow for petrological determination, to be of great service and to give satisfactory results. The net is placed on a sheet of paper and the positions of the various poles marked by pricking through the net. Revolving the net about its central point, we may place the zero-point on any other origin, and read off from the net the distance and azimuth of any face referred to this new origin. If the zonal relations are very complicated, the gnomonic projection may with advantage be employed. By means of the table [2] prepared by the author, the positions of the various poles may be readily determined on any scale that may be suitable to the purpose. The net [3] drawn by Mr. H. Hilton may be used in a similar way.

[1] 'Über die von Professor E. von Fedorow herausgegebenen stereographischen Netze,' Leipzig, Wilhelm Engelmann, 1897. Vide Zeits. Kryst. Min., 1896, vol. xxvi, p. 337.

[2] Min. Mag., 1903, vol. xiii, facing p. 320; and Zeits. Kryst. Min., 1904, vol. xxxix, facing p. 154.

[3] Min. Mag., 1904, vol. xiv, p. 18.

The author has occasionally found it necessary to ascertain the co-ordinates of some face, when referred to an origin other than that from which it has been measured. In case it should not be worth while to remount the crystal, a glass mirror has been provided, circular in shape and swivelled about a diameter. The mirror, when used, is placed so that this diameter is as nearly as possible parallel to the axis of one of the cylindrical adjustments of the crystal-holder. The circles *A* and *B* are set to the known distance and azimuth (subject to any necessary zero-correction), and the mirror is turned about its own diameter and about the axis of *C* until the image, obtained by reflection from it, is symmetrically set on the cross-wires, the final adjustments being made by means of the crystal-adjustment and the slow-motion in the two cases. Rotating about the axis of *C* through the angular amount necessary to bring the new origin into the zero-position, we revolve the mirror about the axes of *A* and *B* until the image, obtained by reflection from it, is again symmetrically placed on the cross-wires, and from the readings of these circles determine directly the new distance and azimuth.

The above procedure is, of course, merely the solution of a spherical triangle, in which the two sides and the included angle are known. By means of the mirror it is possible to solve all cases with two exceptions; when the three sides or the three angles are known, a second mirror[1], inclinable at any desired angle to the first, is required.

The method of measuring crystals on this form of goniometer may be varied to suit the different cases that may arise. For example, in the case of an hexagonal crystal, in which the prism zone is well developed, we should select this zone for reference; but it would be simpler to take measurements from the basal face. To do this, we turn the axis of *C* round that of *B* until the former is at right angles to the axis of *A*. Then, clamping *B* and using the circles *A* and *C*, we derive from *A* the complements of the distances from the base and from *C* the azimuthal angles.

The measurement of twinned crystals is facilitated by the use of this form of goniometer; especially in those numerous cases, in which some one corresponding zone on the two individuals[2] is readily recognizable.

[1] Cf. E. von Fedorow, 'Universalgoniometer mit mehr als zwei Drehaxen und genaue graphische Rechnung,' Zeits. Kryst. Min., 1900, vol. xxxii, p. 481; and K. Stöckl, 'Das Fedorow'sche Universalgoniometer in der Construction von Fuess und die Anwendung dieses Instrumentes zur mechanischen Auflösung sphärischer Dreiecke,' Zeits. Kryst. Min., 1904, vol. xxxix, p. 42.

[2] Cf. Min. Mag., 1902, vol. xiii, p. 146; and Zeits. Kryst. Min. 1903, vol. xxxvii, p. 231.

In such a case, we set up one individual in the usual way and measure it for the identification of the faces, employing for reference the zone which has been recognized; we then turn to the pole of intersection with the corresponding zone on the other individual, and take measurements of both individuals from this pole as origin. The corresponding faces on the two individuals are equally distant from this origin, and are, therefore, easily recognized. The pole of twinning (corresponding to either a face or a zone-axis) is distant a right angle from this origin and its azimuth is half either the obtuse or the acute angle between the zones. Probably only one of these positions is near a crystallographically possible pole, but any doubt is at once removed by a study of a projection of the poles.

Readings of the origin should be taken for each zone in case it has shifted at all from the zero-position. Should it not be correctly adjusted, its pole on the sphere of projection will describe a small circle about the pole of the axis of *B*, and the greatest error introduced in the value obtained for the distance of any other pole from it by neglecting the shift is the distance between the two poles mentioned. In the calculation of the crystallographical constants, it may be best to utilize measurements of distances only, because in this way we measure directly from one image to another and the chance of including errors of adjustment is reduced to a minimum.

The makers of the instrument, Messrs. Troughton & Simms, of London, have in its construction fully maintained the high standard of mechanical skill characteristic of their work, and the author is especially grateful to them for the interest they have taken in the development of the goniometer, and for their readiness to incur any trouble in overcoming the various difficulties that are inevitably encountered in the realization of a new form of instrument.

As some indication of the accuracy that may be expected of this goniometer, the solutions of two pairs of spherical triangles, in which the two sides and the included angle are known, are appended, and the results obtained by observation with the instrument in the manner described in the paper (p. 13) are compared with the computed values. The known sides of the triangles in each pair are identically the same, but the included angles are supplementary. The data have been selected at random, and are given to minutes only, because the scale of the third circle does not admit of greater refinement. Measurements are made in turn from both of the poles, in which the given sides meet the third

(unknown) side, and thus two independent values are obtained for this side; any serious discrepancy between the two would point to some error in setting or in observation.

Given $\begin{cases} b & 74^\circ 27' \\ c & 53\ 42 \\ A & 42\ 25 \end{cases}$ $\begin{cases} b & 74^\circ 27' \\ c & 53\ 42 \\ A & 137\ 35 \end{cases}$

Observed.	Calculated.	O.–C.		Observed.	Calculated.	O.–C.
42° 57′ 4″	42° 57′ 11″	−7″	a	114° 29′ 40″	114° 29′ 16″	24″
107 29 55	107 30 34	−39	B	45 33 57	45 33 58	−1
42 56 50	42 57 11	−21	a	114 29 25	114 29 16	9
52 55 0	52 55 10	−10	C	36 40 35	36 40 48	−13

Given $\begin{cases} b & 65^\circ\ 7' \\ c & 35\ 25 \\ A & 55\ 11 \end{cases}$ $\begin{cases} b & 65^\circ\ 7' \\ c & 35\ 25 \\ A & 124\ 49 \end{cases}$

Observed.	Calculated.	O.–C.		Observed.	Calculated.	O.–C.
49° 58′ 22″	49° 58′ 44″	−22″	a	87° 33′ 22″	87° 32′ 59″	37″
103 27 4	103 27 41	−37	B	48 12 30	48 11 52	38
49 58 0	49 58 44	−44	a	87 32 50	87 32 59	−9
38 24 43	38 24 33	10	C	28 26 17	28 26 17	0

On various minerals (Anatase, &c.), from the Binnenthal.

By R. H. Solly, M.A.

[Read November 17, 1903.]

Anatase.—Some very brilliant and highly modified crystals of a light brown colour were obtained from the Ofenhorn in 1903. The largest crystal measures nearly an inch across. The form {313} is largely developed; other forms present are {100}, {110}, {111}, {331}, {221}, {223}, {335}, {112}, {113}, {117}, and also a new {*h k l*} plane close to (110) and (221), which is probably (24.14.7). These crystals resemble Seligmann's fig. 3 [1].

In 1902 some much smaller, dark brown crystals of a different habit, with the form {117} largely developed, were obtained from another part of the Ofenhorn. They resemble Klein's fig. 3 [2]. Three new forms were observed, namely {553}, {35.3.5}, and {40.3.5}.

(110) : (553) = 13° 16′ (calculated), 13° 20′ (measured).

(35.3.5) in the zones [100, 335], [553, 532].

(40.3.5) „ „ [100, 335], [010, 801].

The other forms observed were {100}, {110}, {111}, {221}, {335}, {801}, {401}, {532}, and {313}, all of which are represented by only small faces.

Laumontite.—Simple greyish-white crystals, some 1½ inches long, were found for the first time on the Ofenhorn in September, 1903. The forms present are *m* (110), *e* ($\bar{2}01$), and *b* (010).

	Calculated.	Measured.
mm'''	93° 44′	93° 40′
$m'e$	66 30	66 15

Albite.—In August, 1903, I found a simple, well-developed crystal in the white dolomite at the Lengenbach quarry. I believe this to be the first time that albite has been noticed as occurring in dolomite. The forms present are: *c* {001}, *x* {$\bar{1}$01}, and *b* {010}, large; *m* {110} and *M* {1$\bar{1}$0}, small; and *f* {130}, narrow. On removal of a fragment the following measurements were obtained:—

	Calculated[1]	Measured.
cm	65° 17′	65° 10′
cb	86 24	86 20

[1] Zeits. Kryst. Min., 1886, vol. xi, p. 337.

[2] Neues Jahrb. Min., 1875, p. 337, plate XI.

Hyalophane.—At the annual meeting of the Mineralogical Society in 1901, I exhibited some twinned crystals of hyalophane, twinned according to the Baveno law of orthoclase. In August, 1903, I found in the Lengenbach quarry two groups with crystals twinned according to the Carlsbad law of orthoclase :—

	Calculated. Baumhauer[1].	Measured. Solly.
$(001):(\overline{001})$	51° 28′	51° 6′
$(\bar{1}01):(\overline{\bar{1}01})$	48 22½	48 15

Three new forms were observed on some small, simple crystals, namely {380}, {$\bar{2}$12}, and {$\bar{2}$11} :—

	Calculated.	Measured.
$(010):(380)$	31° 41′	32° 0′
$(\bar{1}01):(\bar{2}12)$	14 8	14 3

The face ($\bar{2}$11) lies in the zones [$\bar{1}$01, $\bar{1}$10], [010, $\bar{2}$01].

[1] Zeits. Kryst. Min., 1903, vol. xxxvii, p. 605.

The Gnomonic Net.

(*With Plate II.*)

By Harold Hilton, M.A.

Fellow of Magdalen College, Oxford.

[Communicated by Professor Miers, and read February 2, 1904.]

MR. G. F. HERBERT SMITH [1] has pointed out the advantages of the gnomonic projection for some special crystallographic problems. It seems to me that much of the labour in drawing the projections could be saved by a device similar to that employed by Fedorow, Wulff, Penfield, &c., in drawing stereographic projections [2].

Corresponding to the 'stereographic net' described by these authors (which is the stereographic projection of lines of latitude and longitude on a plane through a line of longitude), we have the *gnomonic net*, which is the projection of the lines of latitude (l) and of longitude (m) on the tangent plane at the point whose latitude and longitude are zero. The lines m are parallel straight lines, the lines l are hyperbolae having double contact with each other at two fixed imaginary points. The projection of a point whose longitude is μ and whose latitude is λ is the intersection of the lines $x = a \tan \mu$ and $y^2 \cot^2 \lambda - x^2 = a^2$ (taking suitable rectangular Cartesian axes through O, the centre of the net) [3].

It is not difficult (though rather tedious) to construct a gnomonic net; for the positions of the lines m and their intersections with the lines l are readily obtained by the help of the table given by Mr. Herbert Smith (loc. cit.). An intersection of $x = a \tan \mu$ and $y^2 \cot^2 \lambda - x^2 = a^2$ is the point $(a \tan \mu,\ a \sec \mu \,.\, \tan \lambda)$, and these coordinates are given in the table for every degree from 0° to 65° inclusive. A net showing every other degree [4] is given (Plate II); this should be cut out and pasted on a drawing-board. It is surrounded with a protractor [5] showing every

[1] Min. Mag., 1903, vol. xiii, pp. 309–321.

[2] See, for instance, Zeits. Kryst. Min., 1902, vol. xxxvi, p. 14; Phil. Mag., 1903, ser. 6, vol. vi, p. 67.

[3] In the diagram a = 1·56 inches = 39·64 mm.

[4] As in the stereographic net given by Professor G. Wulff in plate II, Zeits. Kryst. Min., vol. xxxvi, which I have found useful.

[5] Unlike the stereographic net, the gnomonic net does not itself serve as a protractor.

degree. The net is square, and the outer pair of lines m (separating the net from the protractor) correspond to a distance of 65° from the centre of the net[1]. The gnomonic projection of a crystal is drawn on tracing-cloth (or 'Pauspapier'), the centre of the projection being always placed over the centre (O) of the net.

The use of the gnomonic net is so similar to that of the stereographic net that I shall not describe it in detail; it is only necessary to take the account given by Professor G. Wulff[2] of the use of the stereographic net and to apply the necessary alterations. For instance, to find the projection of the pole of a given great circle, turn the tracing-cloth till the projection of the circle is parallel to the lines m and read off the position of the projection of its pole by means of the net. (The projections of a great circle and its pole are polar and pole with respect to the imaginary circle $x^2+y^2+a^2=0$.)[3] Similarly, given the projection of the pole we may find the projection of the corresponding great circle.

To change the plane of a gnomonic projection so that a point whose projection is P may become the centre of the projection, turn the tracing-cloth so that OP is perpendicular to the lines m, and move all points of the projection along the lines l through a distance corresponding to PO. It is best to mark the new positions of the points on another piece of tracing-cloth laid over the first (the net is readily seen through two pieces of good cloth).

To find the angle between two great circles whose projections are PQ and PR, change the plane of the projection so that P becomes the centre of the net and measure the angle between the new positions of the projections of the great circles; or else find the projection (h) of the great circle perpendicular to the two given great circles, produce PQ and PR to meet h in Q' and R', turn the tracing-cloth till h is parallel to the lines m, and read off the angle corresponding to $Q'R'$ on the net.

We can readily find by aid of the net the gnomonic projection of the poles of a crystal measured by means of a two-circle goniometer[4] on

[1] The corners of the net correspond to a distance of 71° 45′ from the centre.

[2] Zeits. Kryst. Min., 1902, vol. xxxvi, p. 15; cf. Phil. Mag., 1903, ser. 6, vol. vi, p. 68.

[3] If we project figures on a sphere from any point V on to any plane cutting the tangent cone from V to the sphere in the conic j, then all circles on the sphere project into conics having double contact with j. It follows that the tangents at the intersection of the projections of two orthogonal spherical curves are conjugate with respect to j. If V is on the sphere, j degenerates into a pair of points. In the projection shown in the diagram j is $x^2+y^2+a^2=0$.

[4] The method may also be applied to crystals measured with a one-circle goniometer,

a plane parallel to the face through which the measured zones pass. We can then find (by the net) the projection of the poles on any other plane. The zones of the projection are then perpendicular to the orthographic projection of the crystal-edges on the same plane (as explained by Mr. Herbert Smith), so that the orthographic projection of the crystal can be readily drawn. It should be noticed, however, that we can find the directions of these edges by means of the stereographic net thus:—Find the stereographic projection on the same plane, and obtain the projections of the poles of the zones; the lines joining these points to the centre of the projection are parallel to the crystal-edges of the orthographic projection.

It should be noticed that the gnomonic projections of the poles of four cozonal faces form a range whose anharmonic ratio is that of the four faces[1]; hence, if we can find the projections of the poles, we can find the anharmonic ratio of the faces (by measuring the actual distances between the projections), even if we do not know the angles between the faces. This is useful sometimes when one of the projections is at infinity[2].

The gnomonic net may be used to solve graphically many problems in cartography or astronomy which can also be solved by the stereographic net. For example:—To graduate a sun-dial. Let P and Z be the gnomonic projections of the celestial north pole and zenith on the plane of the dial. (These points are readily found by means of the net when the position of the plane of the dial is given.) Produce PZ to cut the projection (h) of the celestial equator in R. Turn the projection till the line h is parallel to the lines m of the net, plot off points along h whose distances from R are 15°, 30°, 45°, 60°, &c.[3], and join these points to P; we thus get lines on the dial corresponding to each hour of local apparent solar time. The problem may also be solved (but not quite so readily) by the stereographic net or by the orthographic net (which is the orthographic projection of the lines of latitude and longitude on the plane of a line of longitude).

but the stereographic net is more convenient. This will be clear on a careful reading of Wulff, loc. cit., p. 16, problem 8.

[1] For the pencil of lines joining the poles of the faces to the centre of the sphere is cut by any plane in a range whose anharmonic ratio is that of the four faces.

[2] See Min. Mag., 1903, vol. xiii, p. 315.

[3] If we wished the dial to register apparent Greenwich time in longitude $d°$, we should take points whose distances from R are $(15 + d)°$, $(30 + d)°$, &c.

On Teallite, a new sulphostannite of lead from Bolivia; and its relations to Franckeite and Cylindrite.

By G. T. Prior, M.A., F.G.S.
Assistant in the Mineral Department of the British Museum.

[Read February 2, 1904.]

AMONGST the specimens recently selected for the British Museum from the collection of South American minerals brought together by the late Theodor Hohmann, are two on which occurs a mineral in thin laminae resembling graphite. From the locality and associations, the mineral was at first presumed to be either franckeite or cylindrite, the two sulphantimonite-sulphostannates of lead from Bolivia, which were described in 1893 by Stelzner and Frenzel respectively[1]. Qualitative analysis, however, soon showed that, although similar to them in physical characters, it differed chemically from both franckeite and cylindrite in containing no antimony, but only lead, tin, and sulphur.

Of the two specimens from the Hohmann collection, one was labelled 'sulphoselenide of lead from Bolivia,' and the other 'selenide of lead from Atacama,' so that unfortunately the precise locality of the mineral is at present unknown. In all probability both specimens came from the same district in Bolivia, since in appearance they are very similar.

The new mineral occurs in thin graphite-like folia embedded in glistening kaolin, upon a dark grey matrix impregnated with iron-pyrites; on one specimen it is associated with a little wurtzite in thin plates, and on the other with a little galena.

Crystallographic Characters:—The teallite on the two specimens occurs for the most part in very thin folia with irregular boundaries. A few somewhat thicker plates, however, were found which had a nearly square outline and showed two zones of narrow faces replacing the edges. In each of these zones two sets of narrow pyramid-faces, making angles of 62½° and 75° with the broad cleavage-face, were measured on the three-circle goniometer[2]. Owing to the flexible nature of the plates, the measured angles differed rather widely—from 61° 42′ to

[1] Neues Jahrb. Min., 1893, vol. ii, pp. 114 and 125.

[2] For kind initiation into the manipulation of this instrument I am indebted to Mr. Herbert Smith.

63° 16′, and from 74° 33′ to 75° 58′ respectively—and 62½° and 75° are taken as roughly the mean values. The angle between the two zones measured on the goniometer was 86°. The mineral is therefore in all probability orthorhombic, and not tetragonal as at first supposed. This result was supported by measurement of the angle between two sets of striae, which were observed on some of the plates, running parallel to the edges, and also by observation of the etched figures produced on the cleavage-face by dilute nitric acid. These consisted of two sets of fine striations, like the natural ones, parallel to the edges, and a third set equally inclined to them and occurring only in two opposite (obtuse) corners of the parallelogram formed by the nearly rectangular sets.

Forms observed:—

c {001}, a broad face showing two sets of striations inclined at angles of 86° and 94° and parallel to the intersections with the pyramid-planes.

o {111}, narrow faces often broken up and irregular owing to the cleavage.

p {221}, bright, narrow faces.

Other somewhat doubtful and imperfect narrow faces observed are: *a* (100), *d* (101), *e* (201), and *t′* (211).

Angles measured:—

	Measured.	Calculated.
c : *o* ...	62½°	—
c : *p* ...	75°	75° 25′
c : *a* ...	about 90°	90° 0′
c : *d* ...	„ 57°	54° 33′
c : *e* ...	„ 74°	70° 25′
c : *t′* ...	„ 79°	79° 39′

Angle between the zones [*co*] and [*co″′*] = 86° (i.e. (110):(1$\bar{1}$0) = 86°).

Crystal-system, orthorhombic. Axial ratios,

$$a : b : c = 0{\cdot}93 : 1 : 1{\cdot}31.$$

Crystallographically and in physical characters, teallite shows some relations with nagyagite in which *b* (010) is a perfect cleavage and ϵ (101) : ϵ' (10$\bar{1}$) = 88° 59½′; *b* (010) : *s* (343) = 75° 17½′.

Other Physical Characters:—Cleavage, *c* (001) perfect. Folia flexible, but not elastic. Hardness, 1–2. Teallite does not scratch gypsum, and is thus readily distinguished from franckeite and cylindrite, which scratch gypsum easily. Somewhat malleable, and makes a mark on paper. Like graphite and cylindrite it is difficult to pulverize. Specific

gravity (weight of 1 cc.), 6·36. Lustre, metallic. Colour, blackish-grey. Opaque. Streak, black.

Chemical Composition:—The only impurity associated with the mineral was kaolin, a thin film of which was often found partially coating the cleavage surfaces. This was easily detachable, so that it was possible to obtain very pure material for analysis.

Heated in the closed tube, the mineral gives off a little sulphur and does not fuse. It is readily decomposed by hot, concentrated hydrochloric acid, as well as by nitric acid.

In the quantitative analysis the mineral was decomposed by fusion with sodium carbonate and sulphur, the tin being precipitated as sulphide from the aqueous extract, and the lead as sulphate from the nitric acid solution of the residue. The sulphur was estimated in a separate portion by fusing with sodium carbonate and nitre. The results of two analyses [1], I and II, were as follows:—

	I.	II.	Mean.	Atomic ratios.	Calculated for $PbSnS_2$.
Pb	53·00	52·95	52·98	0·256	53·05
Sn	30·89	29·89	30·39 [2]	0·255	30·51
Fe	0·20	not det.	0·20	—	—
S	16·28	16·30	16·29	0·508	16·44
			99·86		100·00

The numbers obtained correspond very closely with the simple formula $PbSnS_2 = PbS{\cdot}SnS$.

The name *teallite* is given to the new mineral in honour of Dr. J. J. Harris Teall, F.R.S., Director-General of the Geological Survey of Great Britain and Ireland.

Relations of Teallite, Franckeite, and Cylindrite.

In view of the above results and the close similarity in physical characters between the new mineral and franckeite and cylindrite, it seemed desirable to make further analyses of the latter minerals in

[1] The atomic weights used throughout this paper are the 'International Atomic Weights' for 1904, with O = 16. Weights used in analyses, 0·6343 gram in I, and 0·3929 gram in II; for sulphur determinations, 0·2752 gram in I, and 0·2658 gram in II.

[2] In I the tin was determined as oxide by the direct ignition of the sulphide and is possibly a little too high; in II, in order to test for traces of antimony, the sulphide was converted into oxide by means of nitric acid and a slight loss may have occurred. The mean value given above is therefore probably not far from the truth.

order to discover if any closer chemical relationship could be formulated between them and teallite than the mere fact that they all contained lead, tin, and sulphur.

Franckeite from Poopó, Bolivia.

Two specimens were analysed. One was selected as being the most crystalline and homogeneous, since it resembled teallite in showing thin plates with striae. In this case, measurement under the microscope showed that the striae were accurately at right angles and not at 86° or 94° as with teallite. Some of the plates also showed striae inclined at 45° to the rectangular sets, and on one plate occurred a narrow face inclined to the cleavage-face at an angle of 47° 46′. Crystallographically franckeite is probably very similar to teallite, but tetragonal instead of orthorhombic.

The franckeite on this specimen occurs as a vein about one inch in thickness in a porous quartz-rock impregnated with 'feather-ore': it was covered by a patch of brown wurtzite and blende with some iron-pyrites. In picking out material for analysis the chief impurity to be removed was the brown sulphide of zinc. No mechanically intermixed 'feather-ore' could be detected.

The mineral was decomposed by fusion with sodium carbonate and sulphur, as in the case of teallite. The mixed sulphides of tin and antimony were oxidized by nitric acid, and the resulting oxides weighed together: they were then separated by a double fusion with caustic soda. The result of the analysis of carefully selected material, consisting of thin plates, is given under III:—

	III[1].	Atomic ratios.	Calculated for $Pb_5FeSn_3Sb_2S_{14}$.
Pb	46·23	0·224	48·42
Fe	2·69	0·048	2·61
Zn	0·57	0·009	—
Ag	0·97	0·009	—
Sn	17·05	0·143	16·71
Sb	11·56	0·096	11·25
S	21·12	0·659	21·01
	100·19		100·00

Specific gravity (weight of 1 cc.) = 5·88.

[1] Weight used in analysis III, 0·5494 gram; for sulphur determination, 0·2179 gram.

The numbers obtained correspond fairly closely to a formula $Pb_5FeSn_3Sb_2S_{14}$, which may be written $3PbSnS_2 + Pb_2FeSb_2S_8$, i. e. as a molecular compound of a sulphostannite of lead (teallite) with a sulphantimonate of lead and iron.

Another analysis was made on more massive material from a specimen of franckeite from the Trinacria mine, near Poopó. In this specimen no impurity of 'feather-ore' could be detected, but the material did not appear to be absolutely homogeneous, parts being readily cleavable into thin flakes, and parts less easily split up. The analysis was made on material consisting mainly of the more massive and less readily cleavable material, in order to see how it might vary in chemical composition from the more crystalline material used in the preceding analysis. The result of the analysis is given under IV, and that of Winkler's original analysis of franckeite, from Chocaya, Bolivia, under V:—

	IV[1].	Atomic ratios.	V. (Winkler.)	Calculated for $Pb_{4\frac{1}{2}}FeSn_{2\frac{1}{2}}Sb_2S_{13}$.
Pb ...	48·02	0·232	50·57	47·95
Fe ...	2·74	0·049	2·48	2·88
Ag ...	0·99	0·009	Zn 1·22	—
Sn ...	13·89	0·117	12·34	15·32
Sb ...	13·06	0·109	10·51	12·38
S ...	20·82	0·650	21·04	21·47
			Gangue 0·71	—
	99·52		98·87	100·00

Sp. gr. ... 5·92.

The numbers obtained in this analysis approximate to a formula $Pb_{4\frac{1}{2}}FeSn_{2\frac{1}{2}}Sb_2S_{13} = 2\frac{1}{2}PbSnS_2 + Pb_2FeSb_2S_8$, midway between the formula $Pb_5Sn_2Sb_2S_{12}$ $(= 2PbSnS_2 + Pb_3Sb_2S_8)$ of Winkler and the formula $3PbSnS_2 + Pb_2FeSb_2S_8$ given by analysis III. The latter formula is taken as representing the chemical composition of the pure mineral, since the material used in the second analysis was less crystalline and apparently less homogeneous.

Cylindrite from Poopó, Bolivia.

Two specimens, consisting of well-defined cylinders made up of apparently quite homogeneous material, were analysed. The material

[1] Weight used in analysis IV, 0·7185 gram; for sulphur determination, 0·2557 gram.

readily broke up into cleavage-flakes, showing a brilliant metallic lustre but no well-marked striations.

The results of these analyses[1] are given under VI and VII, while under VIII is added that of Frenzel's original analysis of cylindrite:—

	VI.	Atomic ratios.	VII.	Atomic ratios.	VIII. (Frenzel.)	Calculated for $Pb_3FeSn_4Sb_2S_{14}$.
Pb	35·24	0·170	34·58	0·167	35·41	33·70
Fe	2·81	0·050	2·77	0·050	3·00	3·03
Ag	0·50	0·005	0·28	0·003	0·62	—
Sn	25·65	0·215	25·10	0·211	26·37	25·85
Sb	12·31	0·102	12·98	0·108	8·73	13·05
S	23·83	0·743	23·88	0·745	24·50	24·37
	100·34		99·59		98·63	100·00
Sp. gr.	5·46	...	5·49	...	5·42	

The numbers agree fairly closely with the formula $Pb_3FeSn_4Sb_2S_{14}$, which may be written $3PbSnS_2 + SnFeSb_2S_6$, corresponding to the formula $3PbSnS_2 + Pb_2FeSb_2S_6$ of franckeite, with Sn in place of Pb_2.

The above formulae of franckeite and cylindrite, like most of those, not simply empirical, applied to minerals, admit of no real experimental proof; but it may be urged on their behalf that, without doing violence to the analytical results, they serve to suggest a chemical connexion corresponding to the close similarity in physical characters, not only between franckeite and cylindrite themselves, but also between these minerals and teallite.

As regards cylindrite, the close similarity, both in specific gravities and in the analytical results, of the three specimens at present analysed, appears to be good proof that the mineral which occurs in this peculiar cylindrical form has a definite chemical composition. In the case of franckeite the evidence on this point is not so conclusive. Owing to the mode of occurrence of this opaque mineral in radiated or spherulitic aggregates, it is difficult to be assured of its homogeneity. The results of the three analyses at present made certainly show variations in composition, though they all approximate to formulae which can be expressed as mixtures of $PbSnS_2$ with $Pb_2FeSb_2S_6$. The formula, $3PbSnS_2 + Pb_2FeSb_2S_6$, is adopted for franckeite as representing the chemical composition of material which had the appearance of being the most crystalline and homogeneous of the specimens in the British Museum collection.

[1] Weights used in analyses, 0·5684 gram in VI, and 0·6659 gram in VII; for sulphur determination, 0·2446 gram in VI, and 0·2289 gram in VII.

Summary.

Characters of Teallite:—

Grey-black colour, metallic lustre, soils paper like graphite, occurs in flexible folia with nearly square outline, perfect basal cleavage, hardness, 1–2, does not scratch gypsum, density, 6·36. Orthorhombic, $a : b : c = 0{\cdot}93 : 1 : 1{\cdot}31$. Chemical formula, $PbSnS_2$.

Probable chemical formula of franckeite:—

$$Pb_5FeSn_3Sb_2S_{14} = 3PbSnS_2 + Pb_2FeSb_2S_8.$$

Probable chemical formula of cylindrite:—

$$Pb_3FeSn_4Sb_2S_{14} = 3PbSnS_2 + SnFeSb_2S_8.$$

On various masses of meteoric iron reported to have been found in Great Namaqualand and the adjacent region.

By L. Fletcher, M.A., F.R.S.

Keeper of Minerals in the British Museum.

[Read March 22, 1904.]

The Balli Statement.

In November, 1836, Captain (afterwards Sir) James Edward Alexander was at Henkrees (29° S., 18° E.) on the southern side of the Orange River, South-West Africa, and sought for information as to what he might expect to find during his intended journey across Great Namaqualand. He says:—

'A respectable old Bastaard lived at Henkrees, Balli by name; he was the owner of a thousand head of cattle, of many horses and sheep. . . . He also told me of great quantities of copper far up the Great Fish River, and of hills from which malleable iron could be cut out[1].'

This report of Balli's statement, assuming that the accuracy of both report and statement can be relied upon, suggests the occurrence of embedded masses of meteoric iron far up the Great Fish River, at a locality which is hilly, and therefore different from the plain mentioned later by Alexander after his stay at Bethany in March and July, 1837.

The Hahn Statement.

According to a letter sent (1904) to the present writer by Miss M. Wilman, of the South African Museum, Cape Town, Dr. P. Daniel Hahn, of the South African College, Cape Town, was born at Bethany, and was the son of the Rev. Mr. Hahn, the Rhenish missionary at one time located there; he states that his father, when first living at Bethany, saw a great number of meteorites between that station and Berseba (Beersheba), and that the natives used the metal for the making of daggers and other objects.

Bethany is eight days' journey from Angra Pequena. Its mission station was started in 1820 by the Rev. Mr. Schmelen, but by reason of the fighting among the natives was abandoned by him three years after-

[1] 'An expedition of discovery into the interior of Africa, . . .,' London, 1838, vol. i, pp. 144–145.

wards: at the time of Alexander's journey (1837) the station was in ruins[1], and remained so until the Rev. Mr. Knudsen resumed missionary work there in 1843; the station had been abandoned by Mr. Knudsen a short time before the visit made by Andersson in 1852[2].

The Rev. Mr. Hahn referred to in Miss Milman's letter arrived at Bethany in February 1848. Frequent mention of Rev. Mr. Hahn [Rev. C. Hugo Hahn of Barmen (p. 149) and Rev. M. Hahn of Objimbingue (p. 250)] is made in Andersson's 'Notes of travel in South Africa' (London, 1875), and in other books written by the same author; the Rev. C. H. Hahn was not located at Bethany in 1848.

Immediately to the north of Bethany there is a plain, but east and south-east of it there are rugged hills or table-mountains extending to the Great Fish River[3]. Having regard to the physical features of the country between Bethany and Berseba, which is north-east of the former place, it will be seen that the account given by Dr. Hahn is consistent with that which had been given previously by Balli.

The statement recorded by Professor E. Cohen[4] that the Wild mass (to be mentioned later) is said to have lain on the mountains between Bethany and Berseba is doubtless merely a modified and particularized version of the above general account given by Dr. Hahn.

The Thies Statement.

Mr. C. Zerrenner, who prepared for publication (1860) the notes which had been made by the mining engineer, Mr. A. Thies, relative to a journey to the copper mines of Namaqualand, stated in a footnote (p. 53)[5]:—

'At this point of his notes, Mr. Thies intercalates the remark that he has found heavy masses of native iron (Tellur-Eisen), weighing from 450 to 1,000 lb., lying in the bed of the Fish River which rests on granite; he describes the iron as tough, of fibrous fracture, and suitable for being worked at any forge into any kind of tool.'

The name Fish River has been used by Sir J. E. Alexander[6],

[1] loc. cit., vol. i, p. 249.

[2] Andersson, 'Lake Ngami, . . .,' London, 1856, pp. 314, 347.

[3] Alexander, loc. cit., vol. i, pp. 238, 255; Schenck, Petermann's Mittheilungen, 1885, vol. xxxi, p. 134.

[4] Mittheil. aus dem naturw. Verein für Neu-Vorpommern und Rügen, 1900–1, 32 Jahrgang, p. 15; Annals of the South African Museum, 1900, vol. ii, part 2, p. 23.

[5] 'Reise des Ingenieurs A. Thies nach den Kupferbergwerken Namaqua-Land's in Süd-Afrika.' Berg- und hüttenmännische Zeitung, 1860, 19 Jahrgang, pp. 41-43, 53–54.

[6] e.g., loc. cit., vol. i, p. 236.

and also on recent maps, as a substitute for Great Fish River, and Mr. Zerrenner used it in the same sense[1]. The above-mentioned statement must therefore relate to an earlier journey of Mr. Thies; for the journey recorded in the notes was entirely on the southern side of the Orange River, whereas the Great Fish River flows into the latter from the north. Masses of that size are not likely to have been transported to any great distance; for the total weight which can be safely carried in a Cape waggon is about 1,500 lb.[2]

There is no record of the part of the Fish River visited by Thies; the locality may be distinct both from the hills mentioned by Balli and Hahn, and from the plain mentioned in the following statement due to Alexander.

The Alexander Statement.

In the appendix to Sir J. E. Alexander's account of his journey into the interior of Africa (1836–7) is incorporated a short paper by Sir John Herschel containing the following statement[3]:—

'But what constitutes the peculiar and important feature of this discovery of Captain Alexander is the fact, stated by him, of the occurrence of masses of this native iron in abundance, scattered over the surface of a considerable tract of country.'

No particulars relative to the locality of the iron are given in the book, but in the accompanying map the words *much iron* are inscribed on the east side of the Great Fish River at 26° 5′ S., 18° 5′ E. This place being sixty miles distant from his route as marked on the map, Alexander himself cannot have seen the masses: this may also be inferred from a remark made in the paper which was communicated by him to the Royal Geographical Society of London in 1838[4]:—

'There is also *said to be* to the north-east of Bethany, near the Great Fish River, a plain covered with large masses of iron, some of which require several men to lift them. I have got specimens of this iron.'

The Andersson Statement.

Doubtless Mr. Charles John Andersson referred (1856) to the same group of masses in the following paragraph[5]:—

'At eight to ten days' journey with "ox waggon," east of the

[1] loc. cit., p. 41.

[2] F. Galton, 'Narrative of an explorer in Tropical South Africa,' New Edition, London, 1889, p. 14.

[3] loc. cit., vol. ii, p. 274.

[4] Journ. R. Geogr. Soc., 1838, vol. viii, p. 24.

[5] 'Lake Ngami, . . .,' London, 1856, p. 325.

missionary station Bethany, meteoric iron is found in apparently inexhaustible quantities. I have seen lumps, of several hundredweights, brought from thence, so pure and malleable that the natives converted it into balls for their guns, &c., without any previous application of fire.'

In Andersson's map the words *iron found* are inscribed at 26° S., 19½° E., far to the east of the Great Fish River: but the above account suggests that up to that time he, like Alexander, had not visited the district where the masses were lying.

The Schenck Statement.

Dr. Adolf Schenck, who was at Bethany in 1885[1], was informed that the Alexander masses are on the left (i.e. east) bank of the Great Fish River, opposite Berseba; owing to the height of the water he was prevented from going to see them[2].

The Lion River Mass.

A mass of meteoric iron, weighing 178 lb. (81 kilos.), was brought to London in 1852 and purchased by Professor Tennant; it was reported[3] to have been 'found on a clay plain near Lion River in the close vicinity of one or more masses too heavy for transport: the removal of the present lump to the Cape by waggon, a distance of nearly 800 miles over the worst possible roads, being spoken of as attended with no small inconvenience. . . . The box contained several fragments of the clay forming the plain on which the mass was found. . . . The part cut has been done by the Namaquas for fabricating arrow-heads and assagais; the traces of two or three abortive attempts of cutting may also be seen in the surface of the mass.'

Lion, or Kamop, River[4] is a tributary of the Great Fish River, and is shown in Alexander's map at 27° S., 18° E.

The fact that the sender of the Lion River mass forwarded several fragments of the clay, forming the plain in which the mass had been found, shows that he himself regarded the mass as lying where it had fallen. Further, the immediate neighbourhood of one or more masses too heavy for transport to the Cape suggests that the smaller mass had

[1] Petermann's Mittheilungen, 1885, vol. xxxi, p. 132.

[2] Mittheil. aus dem naturw. Verein für Neu-Vorpommern und Rügen, 1900–1, 32 Jahrgang, p. 17.

[3] Amer. Journ. Sci., 1853, ser. 2, vol. xv, p. 1.

[4] Alexander, loc. cit., vol. i, pp. 219, 227.

not itself been transported to the plain. But might not the plain mentioned by Alexander be regarded at Cape Town as being near Lion River? It seems more likely that this should be the case than that two groups of large masses should each be disposed on a plain, and the plains be within a hundred miles of each other, and nearly equidistant from Bethany.

The Wild Mass.

A large mass of meteoric iron, weighing 511 lb. (232 kilos.), has long been exhibited on a pedestal in the South African Museum, Cape Town. In the course of an inquiry into the history of various meteoritic masses, the present writer communicated twenty years ago (1884) with Mr. Roland Trimen, F.R.S., then the curator of the South African Museum, and was informed that 'the specimen in question is without further record than that it was found in Great Namaqualand (that is, north of the Orange River), and was sent to the Museum by Mr. Wild.' In December 1885, Miss Anderson Morshead, of Wiltshire, who had seen the mass at Cape Town and had promised the present writer to seek information from her friends in South Africa, was able to send him the following extract from a letter addressed by Mr. H. Piers, of Cape Colony, to Mrs. H. Reid, one of the daughters of the late Sir Thomas Maclear:—

'There is no record of the original site, only that some trader, finding it at a considerable distance in [Great] Namaqualand, brought it down to the Orange River, and left it on the other side. Long afterwards Mr. Wild brought it to Cape Town.'

Miss Anderson Morshead continued:—

'I asked Mr. Wild's daughter about the mass. Her recollection, as far as it went, was much the same as that of Mr. Piers. I think she believed the mass to have been found [at the Orange River] and sent down by her father (who merely defrayed the expense of transport) a year or so before 1862.'

This specification of the time as 'a year or so before 1862' rests upon hearsay, for Miss Wild was not then born; in the next edition (1886) of the British Museum Meteorite List, the year of the removal of the mass was recorded as 'about 1860.' The statement of Professor Cohen that the mass was lodged in the South African Museum *in* 1860 is doubtless an unintended variation of that record.

In a letter to Mrs. Mann (also a daughter of Sir Thomas Maclear, and sister of Vice-Admiral J. P. Maclear), Mr. Leo Layard furnished the following account given to him in England by his father, formerly curator

of the South African Museum, and at that time (March 1899) too ill to write himself:—

'The large meteorite on the pedestal in the South African Museum was sold by the chief on whose land it fell to a trader for a barrel of rum; the trader took it some distance, and then pitched it out as being too heavy for his waggon. The chief then sold it again to two or three others, each of whom gave more rum for it and carried it a little way. Andersson was the last, and when he got it to Cape Town all the others claimed it, and threatened to go to law. Like sensible people they had a talk over the matter; and, coming to the conclusion that the lawyers alone would benefit by a lawsuit, they all agreed to give the meteorite to the Museum.'

As Mr. Layard, sen., in the same account confused the Victoria West meteorite with that of Cold Bokkeveld, it is possible that his memory was similarly at fault as regards the name Andersson, as might be expected after the lapse of nearly forty years; the name of Wild has long been painted on the pedestal supporting the mass. The true year of the removal to Cape Town becomes an important item in the investigation of the history of the transport and the tracing of the former locality.

It may be inferred from the statement published by Andersson in his work on Lake Ngami[1] that up to 1856 no such mass had been transported by him. In the latter part of that year, while at Cape Town, he was appointed superintendent of the Walfisch (Walfich) Bay Mining Company[2], of which the headquarters were at Objimbingue, Damaraland, and he retained the appointment for twelve months; in March 1858 he went on his voyage of exploration to the Okavango River, returning to Objimbingue a complete invalid at the end of 1859 or the beginning of 1860. After writing an account of his explorations he travelled to Cape Town, presumably by sea, not overland through Bethany. In 1861 he married at Cape Town, and after purchasing the large establishment of the Walfisch (Walfich) Bay Mining Company, settled down at Objimbingue as a trader[3], sending large troops of cattle and sheep overland through Bethany, and across the Orange River, for sale in Cape Colony[4]. It is therefore unlikely that he can have transported any large mass of iron from Great Namaqualand at all after the date at which the Wild mass is said to have been brought

[1] loc cit., p. 325.
[2] 'Notes of travel in South Africa,' London, 1875, p. 333.
[3] loc. cit., p. 2.
[4] loc. cit., pp. 4, 334.

to Cape Town. It follows from Andersson's account[1], and also from the above-mentioned letter of Mr. Layard, that the overland trade between Damaraland and Cape Colony was at that time in many hands: the particular journey mentioned in pp. 4–6 of the 'Notes of Travel' was made probably about 1863; no mass can have been bought from the angry chief at Bethany on that occasion. Galton points out[2] that C. J. Andersson 'must not be confounded with either of two subsequent travellers bearing the same or at least similar names.'

[*Addendum.* According to information sent on July 27, 1904, by Miss Wilman, the transport of the mass must have taken place before April 29, 1857; it has been ascertained that on the last-mentioned date a letter was addressed by Mr. Layard, from the South African Museum, to the Editors of the 'Cape Monthly Magazine[3]' which contains the following statement:—'the huge mass of nearly pure native iron from Namaqualand is exhibited by Mr. John Wild.']

The Mukerop Mass[4].

A mass weighing 392 lb. (178 kilos.) was met with in 1899 at Mukerop, in the district of Gibeon: 25½° S., 18½° E. No particulars of the finding of the mass have been recorded; the mass may have been transported to Mukerop, long before, by the Namaquas or the farmers.

Etched Figures of the Lion River, Mukerop, and Wild Masses.

From a study of the etched figures, Professor E. Cohen at first inferred that the characters of the Wild mass are distinct from those of the Lion River mass; but later, after examination of the Vienna specimen of the latter, he concluded that they are essentially identical: those of the Mukerop mass are likewise similar to the characters of both the Wild mass and the Lion River mass. The British Museum specimens of the three masses quite confirm this view, and leave no doubt that all belong to the same meteoritic fall. How far the dispersion of the masses has been natural, and how far it has been due to the Namaquas and the traders, it seems now impossible to ascertain.

The Springbok River Fragment.

A small fragment of meteoric iron was acquired by Dr. Krantz with the other minerals left by Dr. H. J. Burkart, who died at Bonn in 1874;

[1] loc. cit., pp. 4-5. [2] loc. cit., p. 193. [3] vol. i, pp. 319–320.
[4] Jahresh. des Vereins für vaterl. Naturkunde in Württemberg, 1902, vol. lviii, p. 292.

thence it passed into the collection of Mr. J. R. Gregory, of London, and slices were afterwards distributed by him to various Museums. The only information relative to the history of the fragment is that given on the original label, namely, 'Meteoreisen, Springbock River, Cap d gut Hoffnung (*sic*), Afrika.' In Mr. Gregory's Catalogue, printed in 1889, the part retained by him is mentioned as 'Spring Bok River, Cape Colony, South Africa; small specimen (10 grams); structure very like Lion River.'

The original label gives no clue to the identity of the river, and Mr. Gregory's substitution of the words 'Cape Colony' for 'Cap d gut Hoffnung' rests merely on hypothesis.

The results of a study of the small slice preserved in the British Museum support Mr. Gregory's view as to the general resemblance of the etched figures to those of the Lion River mass; but the figures are distorted near the surface in such a way as to suggest that the specimen has been much hammered during the removal from a large mass. The piece may have been got from one of the Alexander masses, perhaps after transport.

As springboks are plentiful over a considerable part of South Africa, the name 'Springbok River' may have been locally given to various streams: Alexander remarked[1], for instance, that 'the hills about the Fish River abound in klip springer bucks'; Galton reported[2] that 'we passed one great herd of springboks that were migrating . . . It was by no means so numerous a herd as is often seen in Bechuana country; but the tufts of white hair on the backs of the males were as thickly scattered over the country as daisies on a lawn.' A place called Springbokfontein is in Little Namaqualand on an old line of travel from Bethany to Cape Town; another is at the extreme north of Great Namaqualand, due east of Rehoboth.

Nomenclature of the above-mentioned Masses.

Having regard to the probability, but still uncertainty, that these masses belong to a single meteoritic fall, which took place in some district comparatively near to Bethany, and to the desirability of preserving the history of slices taken from different masses, which after all may prove to be distinguishable by later research, it seems advisable not to confound them all under a single name Bethany, but to individualize the masses as Bethany (Lion River), Bethany (Wild), Bethany (Mukerop), and Bethany (Springbok River).

[1] loc. cit., vol. i, p. 239. [2] loc. cit., p. 157.

The Orange River district Mass.

The history of another mass of meteoric iron is very similar to that of the Lion River mass[1]:—

'A mass weighing 328 lb. (149 kilos.) was brought to London in August 1855 from the Cape of Good Hope by the master of a Scottish ship, to whom it had been entrusted by a farmer of the Orange River district, where the mass is supposed to have been recently discovered. It was taken directly to Professor Tennant.'

At the time of Alexander's journey Little Namaqualand was outside the boundary of Cape Colony, but 'a few missionaries had from time to time endeavoured to spread the truths of the Gospel in the district of the Orange River[2]'; this was the region north of the boundary and extending to the Orange River.

The etched surface of the Orange River district mass is entirely different in aspect from that which is common to the Wild, Mukerop, and Lion River masses; the lamellae are of medium, instead of small, breadth. The mass represents a different meteoritic fall; it may have been found in the Orange River district itself, and not transported thither as the Wild mass had been.

[1] Amer. Journ. Sci., 1856, ser. 2, vol. xxi, p. 213.
[2] Alexander, loc. cit., Introduction, p. x.

Historical note relative to the meteoritic fragments labelled 'Cape of Good Hope' and 'Great Fish River.'

By L. Fletcher, M.A., F.R.S.
Keeper of Minerals in the British Museum.

[Read March 22, 1904.]

A SMALL specimen (weighing 20 grams), with a label carrying the inscription 'Meteoric Iron from the banks of the Great Fish River, South Africa,' was included in a mineral collection presented to the British Museum in 1873 by Mr. Benjamin Bright, of Bristol; the collection had been begun by Mr. Richard Bright (1754–1840), and increased by his son, Mr. Benjamin Heywood Bright (1787–1843), father of the donor. No lists or letters were handed over with the collection, and the history of the specimen and its label, prior to 1873, was thus unknown: as no additions to the collection seem to have been made by Mr. Benjamin Bright himself, the Great Fish River specimen had probably been acquired not later than 1843, the year in which his father had died.

The specimen has hitherto been regarded, by reason of its label, as part of the Great Fish River meteorite analysed by Sir John F. W. Herschel, and recorded in a paper entitled 'Notice of a chemical examination of a specimen of native iron from the East Bank of the Great Fish River,' which appeared in the Philosophical Magazine[1] for the year 1839, about the time when the specimen under consideration may have been acquired by Mr. Bright. The fragment examined by Sir J. Herschel, who was then living at the Cape of Good Hope, was one of several which had been given to Captain (afterwards Sir) J. E. Alexander during his journey through Great Namaqualand, perhaps when he was for the second time at Bethany in July, 1837[2]. As no other of the fragments appears to have been preserved, and the behaviour of a polished surface of the iron, on being etched, has not been placed on record, comparison of the characters of the Bright specimen with those of an authenticated Alexander fragment is impossible.

But it can be shown that specimens cut from an iron mass which had

[1] Ser. 3, vol. xiv, p. 32.
[2] Journ. R. Geogr. Soc. London, 1838, vol. viii, p. 24.

been reported by Barrow[1] in 1801, and has long been known to collectors by the name of the Cape of Good Hope iron, may with reason, but inaccurately, have been labelled as 'from the banks of the Great Fish River' by a collector attempting to specify the part of the Colony of the Cape of Good Hope in which that iron mass had been found; the locality is, in fact, some hundreds of miles distant from the Cape from which the Colony itself, and thence the meteorite, had been given the name.

Barrow's statement is as follows:—

'Having recrossed the Great Fish River, we directed our course across a plain towards Graaff Reynet. On this plain was found some years ago, upon the surface of the ground, a mass of pure iron in a malleable state. Considered as a great curiosity, it was carried from place to place and is now in Cape Town. . . . It had probably been the thick part of a ship's anchor.'

The plain indicated by Barrow is about 33° 15′ S., 27° E., and on the western side of the Great Fish River; it does not extend to the bank of the river, but is at some distance therefrom. In 1804 von Dankelmann[2] was taken to the very spot by the son of the finder of the mass, and states that it is between the Sunday River and Bushman River, which are themselves both on the west of the Great Fish River. It is thus inaccurate to label a specimen of the Barrow iron as from the (bank or) banks of that river.

Professor Partsch[3], in 1843, assumed the Great Fish River mentioned by Captain Alexander to be identical with the long-known Great Fish River mentioned by Barrow, and was thus led to express the opinion that the masses recorded by the two explorers belong all to the same meteoritic fall; if such were the case, we should expect them to have identical characters. The etched surface of the Bright specimen is, in fact, indistinguishable from that of a specimen of the Barrow mass, although the kind of etched surface belongs to a rare type.

But on reference to the original work[4], it at once becomes manifest that the Great Fish River of Alexander is different from that of Barrow, and till 1837 had remained virtually unmapped: the locality of the iron masses in question is indicated in Alexander's map, from hearsay statements only, as being 26° 5′ S., 18° 5′ E.; the localities of the Barrow and

[1] J. Barrow, 'An account of travels into the interior of Southern Africa in the years 1797 and 1798,' London, 1801, vol. i, p. 225.

[2] Magazin für den neuesten Zustand der Naturkunde, von J. H. Voigt, 1805, vol. x, p. 12.

[3] 'Die Meteoriten . . . zu Wien,' 1843, p. 132.

[4] 'An Expedition of Discovery into the Interior of Africa (countries of the Great Namaquas, Boschmans, and Hill Damaras)': by Sir J. E. Alexander, London, 1838.

Alexander masses are thus no less than 700 miles distant from each other, as the crow flies.

It is virtually certain that Alexander's book, in the appendix of which Sir John Herschel's paper was incorporated, was inaccessible at the time to Professor Partsch; indeed, the wording of the latter's statement, when critically examined, suggests that he was relying solely on such incomplete information as is given in the Philosophical Magazine reprint of Sir John Herschel's paper: in that reprint there is nothing to indicate that the Great Fish River mentioned therein is not the better-known one to which the name had been long applied.

Having regard to the rarity of the specimens belonging to this type of meteorite, and to the absence of reliable evidence of so wide a spreading of masses belonging to any meteor, the question arises as to whether the Bright specimen may not have been cut from the Barrow mass, and have no relation to Captain Alexander at all. That this is really the history of the specimen is rendered certain by the following considerations.

The London mineral dealer and author, James Sowerby (1757–1822), owned in the year 1806 a large piece of the Barrow mass; he figured and described it in his 'Exotic Mineralogy[1],' published in 1817:—

'Fig. 3 is my specimen of the iron found near the Great Fish River; it was obtained at the Cape of Good Hope and brought to England by Fichtel. (The piece brought to England formerly by General Prehn I understand was sent to Holland.) . . . These properties rendered it an excellent material for a sword blade, consequently upon his Majesty the Emperor of Russia visiting England I had a slice $2\frac{3}{4}$ inches long, 2 inches wide, and nearly $\frac{3}{4}$ inch thick, hammered at a low red heat into a blade 2 ft. long and $1\frac{1}{2}$ inches wide—which, welded into a steel haft and mounted, I presented to his Majesty as a memorial of his visit. Previously to this a slice had been sawn off by Smithson Tennant. . . . The mass originally found was carried from place to place as a great curiosity; its weight was estimated by Barrow at about 300 lb.'

Probably Mr. Sowerby's piece was the only one from which collectors could obtain specimens of the Barrow iron by the method of purchase. According to Mr. Smithson Tennant[2], the piece was about 6 inches long, $4\frac{1}{2}$ inches broad, and 2 inches thick.

After the death of Mr. James Sowerby in 1822, the business passed into the hands of his son, Mr. George Brettingham Sowerby (1788–1854). That the latter possessed some of the Barrow iron as late as 1842 is proved by the fact that a hammered lamina of it was purchased directly

[1] Vol. ii, p. 137. [2] Tilloch's Philosophical Magazine, 1806, vol. xxv, p. 182.

from him for the British Museum in October of that year; there was no label with the specimen, and no letters passed relative to the purchase: hence there is no evidence as to how Mr. G. B. Sowerby would have named the specimen. Mr. Charles Konig recorded, in the departmental archives, the purchase as being that of 'A laminated portion of the Cape meteoric iron of which a sword was made by Mr. Sowerby for the Emperor Alexander.'

And not long before, in 1840, a specimen had been acquired by Professor Partsch (through Mr. Bondi) from Mr. Heuland, of London, for the Vienna Collection. Professor Partsch adds:—

'It comes from the mineral collection of the late Mr. Sowerby, who possessed a large piece of the Cape Iron brought by Barrow [i.e. Fichtel] to England, and of which he had a sword forged for the Emperor Alexander of Russia.'

On comparison of the handwriting on the label of the Bright specimen with letters sent by Mr. G. B. Sowerby at various times to Mr. Konig, it becomes manifest that the label must have been written by him.

As the Alexander fragments were not then represented in the British Museum Collection, it is unlikely that Mr. G. B. Sowerby, if in possession of a specimen of the iron, would have disposed of it to a Bristol collector without first offering it in London. On the other hand, there is no evidence at all that Mr. Sowerby, or any other dealer, ever possessed one of the fragments brought back by Captain Alexander.

It may be added that the twelve other meteoritic specimens in the Bright Collection belonged all of them to falls well represented in 1843 in the British Museum and elsewhere, and that at least one of them (Red River) had been acquired from Mr. G. B. Sowerby.

All things considered, there can be no hesitation in concluding that the Great Fish River specimen in the Bright Collection had been acquired by Mr. Bright from Mr. G. B. Sowerby, and had been cut from the piece which Mr. James Sowerby had obtained from the Cape mass first recorded by Barrow: the label provided by Mr. G. B. Sowerby was doubtless based on the above-mentioned paragraph of his father's book.

It may also be inferred that the fragments brought back from Bethany by Captain Alexander were small bits, which had been broken from one or other of the masses, with the help of a hammer and chisel, and were suited rather for analytical than etching purposes; possibly they were fragments broken off by the Namaquas and intended for use as arrow-heads[1]: that examined by Sir J. Herschel weighed only 1·4 gram.

[1] Compare Amer. Journ. Sci., 1853, ser. 2, vol. xv, p. 1.

Note relative to the history of the mass of meteoric iron brought by Dr. F. P. Moreno from Caperr, Patagonia.

By L. Fletcher, M.A., F.R.S.
Keeper of Minerals in the British Museum.

[Read March 22, 1904.]

THE mass of meteoric iron brought from Patagonia[1] in 1896 by Dr. Francisco P. Moreno, Founder and Director of the State Museum of La Plata, had been sought for by him, while exploring that region, because of a reference which had been made to it in Captain G. C. Musters's book, 'At Home with the Patagonians,' published in 1871.

Dr. Moreno believed the mass to be really identical with a block of supposed marble, referred to on page 87 of that work as having been seen by Captain Musters in 1869 at Amakaken, which is situated in longitude 71° 56′ W. and latitude 48° 10′ S.

As Dr. Moreno found the mass of iron not at Amakaken, but at longitude 70° 20′ W. and latitude 45° 15′ S., not far from the tribal encampment Caperr (Capperr or Capper), south of Rio Senguerr (or Senguer), there was great discrepancy as regards both the nature of the material and the position and name of the encampment or village; the discrepancy was thought to be a result of confusion of memoranda, or lapse of memory, on the part of Captain Musters, who died as long ago as 1879.

Caperr is indicated as *Capper* on the 'Plano preliminar y parcial de los territorios del Neuquen, Rio Negro, Chubut y Santa Cruz,' published in tomo ix, 1899, of the Revista del Museo de La Plata, dirigida por F. P. Moreno.

Through the courtesy of Professor Rodolfo Hauthal, of the Geological Section of the Museum of La Plata, my attention has been called to the following paragraph from page 101 of the book of Captain Musters, in which specific mention is made of a mass of iron heard of, not seen, by the author:—

'In the range of hills described as visible from Kaimak, there is

[1] Revista del Museo de La Plata, 1898, tomo viii, p. 305: plate 34 of the same volume gives a figure of the mass. Mineralogical Magazine, 1899, vol. xii, p. 167.

a mine or vein of iron ore, about a mile due west from the brook, and marked by a large mass of white quartz. This is used by the Indians in the manufacture of bolas, and an excursion was made to it. We brought back numerous pieces, some of which, now in my possession, have been examined and pronounced to be brown and magnetic iron ore. The Indians also told me that some leagues to the east of this spot a mass of iron, having, as well as could be gathered from their account, the shape of a bar-shot, lies in the middle of a barren plain, and is regarded by them with superstitious awe. Whether this be an aerolite, or has any connection with the ore on the hill side, it was not in my power to determine, for in the critical state of feeling then prevalent, a visit of inspection was impracticable.'

Yaiken-Kaimak is shown in Musters's map at longitude 72° W. and latitude 45° 45′ S.: 'some leagues to the east of' Kaimak would thus agree satisfactorily with Dr. Moreno's statement of the locality where the iron-mass was found.

There can thus be no doubt that the block transported by Dr. Moreno is the one mentioned on page 101, not that mentioned on page 87, of the late Captain Musters's book.

Irregularly developed crystals of Zircon (sp. gr. 4·0) from Ceylon.

By L. J. Spencer, M.A., F.G.S.
Assistant in the Mineral Department of the British Museum.

[Read March 22, 1904.]

SOME small isolated crystals from the gem-washings in Ceylon, recently sent by Mr. A. K. Coomáraswámy to the British Museum for determination and study, were at first thought to be rutile, but on detailed examination proved to be zircon of a rather unusual type. This has a specific gravity of 4·0, which is not increased when the crystals are heated.

The majority of the crystals are from the Balangoda district in the Sabaragamuwa province, and, according to Mr. Coomáraswámy[1], have been derived from a group of zircon-granites which occur in this district; a few others are from Walaweduwa in the Bamberabotuwa district, and from the Hatton district. Associated with them are zircons of more usual types (see p. 48); the present description is, however, confined to the crystals of lower specific gravity.

On placing the samples as received in molten silver-thallium nitrate with indicators of corundum (sp. gr. 4·0), almandine (4·1), willemite (4·15), rutile (4·2), and barytes (4·5), it was found that the specific gravity of the different crystals varied from 4·0 to over 4·5, the darker coloured crystals being less heavy and the lighter coloured more heavy. Only a few of the crystals have a specific gravity of exactly 4·0, these being of a dark brown colour and almost opaque. The majority are slightly heavier and show a transparent patch of a yellowish-brown colour on one side. As this lighter coloured portion increases in amount in the different crystals so does the specific gravity; and between 4·0 and about 4·2 there is an unbroken series.

The largest crystal (measuring $10 \times 5 \times 3$ mm. and weighing 0·592 gram) was found by hydrostatic weighing to have a specific gravity of 4·00; this crystal is in all portions of a dark brownish-black colour, and, except on thin edges, is opaque. Other, rather smaller, crystals were also separately weighed in water and found to have specific

[1] Geol. Mag., 1904, new ser., dec. 5, vol. i, p. 418.

gravities of 4·02, 4·03, and 4·09 respectively; these all showed a lighter coloured and more transparent portion.

The crystals have an average size of half a centimetre across. Their hardness is 7. They are developed on all sides and only very rarely show any broken surfaces. Owing to the very irregular development of the crystals it was not at first easy to determine their symmetry, especially as the faces are somewhat rough and give only blurred images of the goniometer-signal. Further, zircon having in four zones [$ax = 31° 43'$, $xp = 29° 57'$, $pe = 28° 20'$] angles of nearly 30° and in three zones [$am = 45°$] [$mp = 47° 50'$] angles of 45° or nearly 45°, it was not

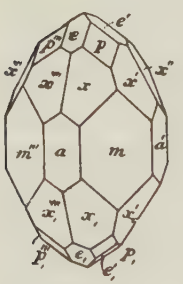


Fig. 1.
Ideal development.

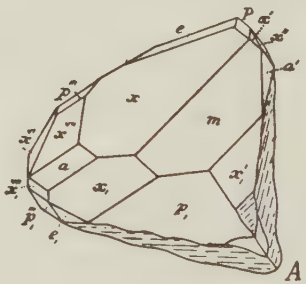


Fig. 2.
Actual crystal.

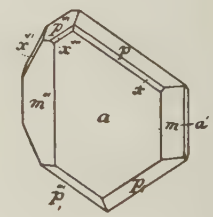


Fig. 3.
Actual crystal.

Zircon from Ceylon (Clinographic drawings and plans) [1].

always possible to distinguish the approximate measurements obtained from the angles of a cubic crystal, or to correctly orientate the crystals, until several zones on each had been measured.

The accompanying figures (figs. 2 and 3) are intended to give an idea of the shape of two of the crystals, while fig. 1 represents an ideally developed crystal with the same forms. The forms present are: a {100}, m {110}, e {101}, p {111}, and x {311}.

A peculiar feature presented by almost all the crystals of low specific

[1] The method of giving a plan of the crystal together with the clinographic drawing is borrowed from H. H. Robinson (Amer. Journ. Sci., 1901, ser. 4, vol. xii, p. 180).

gravity is that on one side they show an area of deeply striated and stepped surfaces. These surfaces usually lie in the principal zones of the crystal, and meet in a central point (*A* in figs. 2 and 3) to form a pyramid, which in most crystals is quite flat and has its base parallel to *a* (100) or *m* (110). The zones in which they are most prominently developed are [100, 010], [100, 111], and [100, 1$\bar{1}$1], the low striated pyramid being then six-sided, as in fig. 3. (In the crystal here represented, however, one set of the striated surfaces is not quite in the zone [100, 111].)

At the centres, *A*, of these striated areas the crystals are pale yellow in colour, transparent, and possessed of a brilliant adamantine lustre. Away from this point the colour gradually shades off into brown, and the transparency and lustre diminish. The striated surfaces reflect long bands of images, but sometimes there are bright and smooth faces from which fairly good measurements, agreeing with the angles of zircon, could be obtained. On one crystal the centre of the area is occupied by a small projection having the form of a square pyramid bounded by (111), (11$\bar{1}$), (100), and (010).

The appearance presented by these striated areas is very similar to that shown by the individual crystals broken from a divergent group of crystals which have interfered with each other's growth. It would seem that several crystals had originally grown around a common centre, in which the points, *A*, of all the crystals coincided; the lighter and brighter striated surfaces would then have been the surfaces of contact between adjacent crystals; and the dull brown, freely-developed faces would represent the external boundaries of the whole group. The fact that the striated surfaces fall in the principal zones would further suggest that the crystals had some definite arrangement with respect to each other, and that the composite crystal was probably of the nature of a pseudo-symmetric or mimetic group. It is quite possible, however, that the crystals grew separately, and that their growth on one side was simply retarded by contact with some other body. The striated pyramidal portions of some of the crystals bear a striking resemblance to the so-called 'babel-quartz' from Beeralston in Devonshire, but they differ from this in having freely-developed faces on the opposite side.

When viewed through the prism-faces in parallel polarized light, the crystals extinguish uniformly parallel to the principal axis. Sections cut perpendicular to this axis are quite transparent and exhibit, in convergent polarized light, interesting variations in the optical characters.

Two sections (sp. gr. 4·1) taken through both the dark and light coloured portions of one crystal (sp. gr. 4·02) showed a gradual transition from colourless through pale yellow to rich brown, the last predominating in amount. In the small colourless portion (which is at the tip *A* of the striated area of the crystal) the section is biaxial with a small axial angle ($2E = 8°$ about), the axial plane being perpendicular to the prism-face *a* (100) on the opposite side of the crystal; the birefringence is very strong and positive. On moving the plate so that the coloured portion gradually comes into the field, the axial angle gradually diminishes in size until the figure becomes strictly uniaxial (+); at the same time the numerous coloured rings gradually expand outwards and become further apart. On moving the plate still further in the same direction, the rings continue to expand and at last disappear; finally the black cross also disappears, and, in the darkest brown portion, the section is perfectly isotropic. The greater portion of the section is optically uniaxial with weak positive birefringence.

The section, although showing such wide differences in the strength of its double refraction, has about the same mean refractive index in all parts. This was determined, by focusing on the scratches on the two sides of the section, to be about 2·0[1]: the scratches on the under side remained in focus as the section was moved about on the stage of the microscope.

Three other sections cut from two small brown crystals (sp. gr. 4·0) on which there was none of the lighter coloured portion, showed by transmitted light a brown colour of varying depth in different parts. These sections were also, for the most part, optically uniaxial with weak positive birefringence; the strength of the double refraction, however, varied slightly in different parts and was sometimes almost zero; in one or two places in one section the figure was biaxial with a slight separation of the optic axes.

When heated to redness in the flame of a Bunsen burner, the crystals change in colour from dark brown to bright green, and become much more transparent and lustrous. No phosphorescence was observed; and there was practically no loss in weight. By immersion in silver-thallium nitrate, it was determined that the crystals of specific gravity 4·0 had the same specific gravity after ignition as before, but that crystals with a slightly greater specific gravity (up to 4·1) showed a slight increase (up to 4·2).

[1] The mean of ten approximate readings, varying between 1·9 and 2·1, was 1·97. The section has a thickness of about 1 mm.

The sections after being heated to redness showed changes in their optical characters. The portions which were before brown are now green, and between crossed nicols, in parallel light, are doubly refracting with undulose extinction. In convergent polarized light the optic figures are confused and distorted, but positive biaxial figures with axial angles up to 20° and with axial planes of variable orientation can sometimes be distinguished. The birefringence is still low, though rather stronger than before. The small colourless portion in the sections of the first crystal remained, as before, biaxial with strong birefringence. The mean refractive index of the whole plate was also unchanged. When the crystals and sections were still more strongly heated over the bellows-blowpipe, no further change took place.

Absorption bands in the spectrum of light which had passed through the crystals were sometimes observed, but only after ignition.

The crystals described therefore consist mainly of a dark brown zircon of specific gravity 4·0, which is optically uniaxial with weak positive birefringence; when heated, this material changes to green in colour and becomes optically biaxial, but undergoes no change in specific gravity. Intergrown with this variety, in most crystals, there is a lighter coloured variety of zircon of higher specific gravity, which is biaxial with strong positive birefringence; this variety when heated increases in density, but shows no change in its optical characters. The two varieties are identical in crystalline form.

A chemical examination of one crystal of low specific gravity showed the presence of much silica and zirconia, and the absence of titanium. From a neutral solution containing the zirconium, oxalic acid threw down a bulky white precipitate which was very readily soluble in excess of oxalic acid; potassium zirconium sulphate was precipitated from a neutral sulphate solution; and a satisfactory colour was obtained with the turmeric-paper test for zirconium. Comparative tests were made with a red zircon from Expailly (sp. gr. 4·7), and the reactions were apparently the same for this as for the Ceylonese crystal. It is, however, quite possible, as suggested by Stevanović[1], that in one of these zircons there may be instead of zirconium another closely allied element.

From his own observations and from those of Professor A. H. Church[2], it has recently been pointed out by Dr. S. Stevanović[3] that zircons may

[1] Zeits. Kryst. Min., 1903, vol. xxxvii, p. 252.

[2] Journ. Chem. Soc. London, 1864, new ser., vol. ii, pp. 389, 415; Geol. Mag., dec. 5, new ser., dec. 2, vol. ii, p. 322; Chem. News, 1902, vol. lxxxv, p. 270.

[3] Zeits. Kryst. Min., 1903, vol. xxxvii, p. 247.

be divided into three classes according to their different specific gravities and behaviour when heated, viz.:—

(i) Sp. gr. 4·0, both before and after ignition. (α-zircon.)

(ii) Sp. gr. 4·7, also unchanged by heating. (β-zircon.)

(iii) Sp. gr. between 4·0 and 4·7; when strongly heated the zircons of this class increase in density, reaching sometimes the higher limit.

The stable modifications of lower and higher specific gravity may be distinguished as α-zircon and β-zircon respectively. The former kind, to which the dark brown crystals described above belong, appears to have been noticed previously only twice. Church (1875) mentions a dark green stone of sp. gr. 4·02, which experienced no change in density when heated. Stevanović (1903) has described brown pebbles from Ceylon of sp. gr. 4·06, which showed a slight change from 4·02 to 3·965 when strongly heated; the colour at the same time passing to siskin-green and the transparency increasing: both before and after ignition the material was optically uniaxial with very feeble positive birefringence. The material described in the present note is thus very similar to that examined by Stevanović, though it shows some differences in the optical characters.

A zircon of low specific gravity is not necessarily α-zircon, for Damour[1] records a green stone from Ceylon which increased in density from 4·043 to 4·318 when heated; and Church (1902) mentions a green Ceylonese zircon which changed from 4·0 to 4·31. These belong to the third class, and may be inferred to consist of an intergrowth of α-zircon with an unstable modification (γ-zircon), which increases in specific gravity to 4·7 when heated. Specimens (all[2] of sp. gr. greater than 4·33) which increase in specific gravity to the higher limit (4·7) can contain no α-zircon, though they may consist of an intergrowth of β-zircon and γ-zircon. The fact that zircons of the third class frequently exhibit zonal structures amply supports the supposition of these intergrowths.

These variations in the specific gravity and optical characters of zircon give rise to many suggestions, but as Professor Church and others are still engaged on this work I merely offer the results of my determinative examination of the crystals described above as a contribution to this most interesting problem.

[1] Compt. Rend. Acad. Sci. Paris, 1864, vol. lviii, p. 158.

[2] The lowest recorded is by Stevanović (loc. cit., p. 250), who describes greenish crystal-fragments, from Ceylon, which increase in sp. gr. from 4.33 to 4.66, at the same time losing their colour and changing from optically biaxial to uniaxial.

The construction and use of the Moriogram.

(*With Plate III.*)

By G. F. Herbert Smith, M.A., F.G.S.

Assistant in the Mineral Department of the British Museum.

[Read March 22, 1904.]

THE diagram (Plate III), to which for convenience the author has given the name moriogram[1], is intended to provide a method for rapidly determining the angles between a face of symmetry and all other faces with rational indices, which lie with it in some particular zone, when two of the angles are known, or, what is precisely the same thing, between a zone of symmetry and all other zones with rational indices, which intersect it in the same pair of opposite poles, when two of the angles are known: whenever possible it should be arranged that one of the known angles is a right angle. The moriogram may, therefore, be used in the course of computation for checking the accuracy of the work, or during the goniometrical measurement of a crystal for finding the relations subsisting between the faces or the zones.

The discussion—without, however, the loss of any generality—will be simplified if we consider a particular case, say that of the zone [*ab*], [100,010]. We will first suppose the angle *ab* (100 : 010) to be a right angle.

Let the angle *am* (100 : 110) be θ, then the angle between *a* (100) and any other face in the zone is $\tan^{-1} x$, where x is one of the values given by

$$x = y \tan \theta,$$

y being a simple whole number or a fraction composed of simple whole numbers.

If now we take x and y as Cartesian coordinates and assign to θ the values 0°, 1°, 2°, ... and so on, up to 90°, we obtain a pencil of rays emanating from the origin, each of which is inclined to its immediate neighbours at an angle of 1°.

We notice that, when $x = y$, $\tan \theta = 1$, and that therefore the unit distances on the two axes are equal. If the unit distance from the origin on the axis of Y be divided into rational parts, and lines be drawn through these points parallel to the axis of X, their intersections with the particular ray of the pencil in question give us at once the

[1] μόριον, a part.

angles required. If the unit distance on the axis of X be divided so that the distance of any point from the origin represents the tangent of the corresponding angle, we may read off from the diagram the angles mentioned above. Lines drawn through the point on this axis representing any particular angle intersect the corresponding ray of the pencil in the line $y = 1$.

As yet we have merely considered fractions less than unity, that is to say the indices of faces lying between $a\,(100)$ and $m\,(110)$. Suppose, however, we write $\frac{1}{y}$ for y in the equation to the ray, we obtain

$$xy = \tan\theta,$$

i.e. a rectangular hyperbola, the asymptotes of which are the coordinate axes. This curve corresponds exactly to the ray and may be used in precisely the same way; the only difference is that the ratio of the indices has been inverted, and we now obtain the indices of faces lying between $m\,(110)$ and $b\,(010)$ without passing beyond the boundary $y = 1$.

In the same way we may see that the moriogram need not extend beyond the boundary $x = 1$. The effect of writing $\frac{1}{x}$ for x, which we remember represents the tangent of some angle, is to give us the cotangent of the same angle. The hyperbola now becomes the ray

$$x = y\cot\theta = y\tan(90^\circ - \theta),$$

which may be termed the complement of the previous ray.

Hence finally we perceive that the moriogram is bounded by a square, a side of which is the unit distance. A pencil of rays, one for every degree in the right angle, radiates from one corner, every fifth ray being drawn darker. Except in the case of the ray bisecting the right angle the intersections of the complementary rays with the opposite sides of the square are connected in pairs by rectangular hyperbolae, every fifth of which is also drawn darker. Traversing the moriogram are series of vertical and horizontal lines. The former lines cut the side which has above been termed the axis of X, such that the abscissae represent the tangents of some angle; again every fifth line is drawn darker. The horizontal lines divide the sides of the square at right angles to them into all fractional parts not involving numbers greater than 10. To avoid too great complexity, certain of the lines, namely those corresponding to the parts with the numbers 7 and 9 as denominators, have been drawn fainter. If the tenths of divisions be estimated we may read to 6′; but for most ordinary purposes accuracy to 30′ would be quite sufficient.

It may be noted that the known angle need not necessarily be *am* (100 : 110); it may just as conveniently be the angle between *a* (100) and any other face—except, of course, *b* (010)—lying in the zone.

As an example of the use of the moriogram, the readings observed for the principal zones of cerussite are given and compared with the values obtained by calculation.

Three Principal Zones of Cerussite.

	Measured from (100). Observed.	Calculated.
(530)	20° 5′	20° 6′
(110)	*	31 23
(350)	45 30	45 28½
(120)	50 40	50 39½
(130)	61 25	61 25½
(180)	78 20	78 25

	Measured from (001). Observed.	Calculated.
(105)	13°15′	13°20′
(104)	16 25	16 30½
(103)	21 25	21 33½
(102)	30 35	30 39
(101)	*	49 51
(302)	60 45	60 39
(201)	67 15	67 7½

	Measured from (010). Observed.	Calculated.
(0.10.1)	7°50′	7°52½′
(091)	8 35	8 44
(081)	9 55	9 48½
(071)	11 5	11 10½
(061)	13 0	12 59
(051)	15 25	15 27½
(041)	19 5	19 4½
(031)	24 40	24 45
(052)	28 55	28 57
(021)	34 35	34 40
(032)	42 40	42 41
(076)	49 50	49 51
(087)	50 25	50 26
(011)	*	54 8
(023)	64 15	64 16
(012)	70 10	70 7½
(013)	76 30	76 27
(016)	83 5	83 8

The moriogram may, though not so readily, be used in cases where no right angles are available. Thus suppose the angles *ab* (100 : 010) and *am* (100 : 110) are ψ_0 and ψ_1 respectively. The course of procedure may be seen from the following equations:—

$$\frac{\cot\psi_1 - \cot\psi_0}{y} = \frac{\cot\theta_1}{y} = \frac{1}{x} = \cot\theta = \cot\psi - \cot\psi_0.$$

Having found θ_1 we proceed in precisely the same way as before in the case where ψ_0 was a right angle, to find the values of θ corresponding to the indices of the faces in question.

The derivation of θ_1 from ψ_1 or of ψ from θ may be made graphically from the moriogram. The intercepts made on any vertical line by the

rays of the pencil are, when measured from the axis of X, i. e. the lower side of the square, directly proportional to the cotangents of the corresponding angles. By means of dividers we can subtract $\cot\psi_0$ from $\cot\psi_1$. A convenient method is to use strips of paper divided on the edges exactly as the vertical lines in the moriogram corresponding to the angles 5°, 10°, 15°, 20°, 25°, 30°, 35°, 40°, 45°; or perhaps better still to use a square sheet cut slightly larger than the square boundary of the moriogram, the eight edges, four on either side, being divided as the lines mentioned, omitting the first. Selecting the most convenient of these lines, i. e. the one furthest from the origin which meets all the rays in question within the limits of the moriogram, we place the point marked 90° on one scale on that marked ψ_0 on the other, and convert immediately from θ° to ψ, or vice versa. The author has found it on the whole more convenient to keep this conversion distinct from the moriogram itself, and employs the following method :—four scales of cotangents (cot 45° being represented by 20, 10, 5, and 2 cm. respectively) are drawn on a sheet of paper and four scales identical with the above are drawn, two on either side, on a strip of paper; the procedure is the same as before.

As an example the readings obtained for the zone [100,001] of epidote are added and compared with the computed values :—

Zone [100,001] *of Epidote.*

	Observed.		Calculated.	
	Moriogram.	Corrected.		
(3̄01)	14°45′	16°45′	16°46′	Measured from (1̄00).
(2̄01)	21 40	25 55	25 57	
(3̄02)	27 55	35 10	35 4½	
(4̄03)	30 50	39 40	39 32	
(1̄01)	38 25	51 40	51 41	
(3̄04)	46 35	64 40	64 38½	
(2̄03)	49 55	69 45	69 46	
(1̄02)	57 50	81 0	81 2	
(1̄03)	67 20	93 10	93 2	
(1̄04)	72 30	99 1	99 0	
(001)	90 0	*	64 37	Measured from (100).
(105)	75 55	54 0	53 58	
(102)	57 50	42 15	42 6	
(101)	38 25	*	29 54	
(201)	21 40	18 15	18 25	
(301)	14 45	13 0	13 11	

To draw the curves, their intercepts on every ray of the pencil were calculated, and the points thus determined were pricked off on the diagram. Since from the equation

$$xy = \tan\theta,$$

we have

$$\frac{dy}{dx} = -\frac{y}{x} = -\tan\phi = \tan(180° - \phi),$$

where $y = r\sin\phi$, $x = r\cos\phi$, r and ϕ being radial coordinates, we see that the tangents to the curves at all points lying on the same ray are parallel, and that the ray and any tangent make supplementary angles with the same coordinate axis. The curves were developed by means of the tangents. Their direction for points lying on the same ray were conveniently found by means of the form of protractor[1] devised by the author for plotting gnomonic projections, and they were drawn for each curve in succession by sliding the protractor along a straight-edge. Finally, for the inking of these curves the templates[2] devised by Professor R. H. Smith were employed.

[1] Min. Mag., 1903, vol. xiii, p. 313; Zeits. Kryst. Min., 1904, vol. xxxix, p. 146.

[2] Set of 'R. H. S. Curves,' by Professor Robert H. Smith, published by Cassell & Co., London.

Note on cobaltiferous Mispickel from Sulitjelma, Norway.

By the Rev. Mark Fletcher, M.A., F.G.S.

Vicar of North Sunderland; Lecturer in Mineralogy at the Durham College of Science, Newcastle-upon-Tyne.

[Read June 7, 1904.]

SOME months ago Professor Henry Louis presented to this college several isolated crystals which he had brought from the Sulitjelma (or Sulitelma) mines in Arctic Norway: they occur there in masses of copper-pyrites and iron-pyrites, for which this district has been famed for some years.

The crystals are of various sizes, ranging in length from 4 to 8 mm. They have a metallic lustre and silver-white colour. The fracture is uneven, and no cleavage is visible. On a freshly broken surface small yellow particles can be seen with the naked eye; these also have a metallic lustre, and are probably iron-pyrites, a probability which is strengthened by the appended chemical analysis. The specific gravity varies from 5·94 to 6·02, and the hardness is just under 5. The crystals are all of a pronounced rhombic aspect. Three of them were measured, and the forms present were found to be {011}, {012}, and {110}; the faces of the forms {011} and {012} are faintly striated parallel to their edges of intersection.

Two of the measured crystals are simple, and the third is a composite growth of two interpenetrant individuals. This latter approximates to a twin, of which the twin-plane is (210); but it is only approximation, the difference between the observed and calculated angles being too large to justify the recognition of a new twin-plane, especially as this relation of the individuals was only found in a single instance.

The means of the best readings of the angles of the simple crystals are the following:—

	Measured.		Calculated.
(011) : (01$\bar{1}$)	80° 0½′	...	—
(011) : (012)	19 16½	...	19°12½′
(012) : (0$\bar{1}$2)	61 37	...	61 34
(110) : (1$\bar{1}$0)	69 6	...	—

From the above angles we derive the axial ratios:—

$$a : b : c = 0{\cdot}6886 : 1 : 1{\cdot}1915.$$

These axial ratios suggested that the specimens are crystals of glaucodote; but the following two analyses by Dr. J. A. Smythe, of the Durham College of Science, show that the material is mispickel, containing about one per cent. of cobalt and thus approaching to the variety known as danaite.

	I.	II.	Mean.	Atomic ratios.
S	21·76	21·96	21·86	0·683
As	42·20	42·15	42·18	0·562
Fe	35·31	36·17[1]	35·31	0·632
Co	1·32	0·98	1·15	0·020
	100·59	101·26	100·50	

The atomic ratios show an excess of iron (0·090) and a still greater excess of sulphur (0·121) over that required by the formula (Fe,Co)AsS; this is probably owing to the mechanical intermixture of iron-pyrites, yellow specks of which on the fractured surface are visible to the naked eye.

It remains to be mentioned that crystals of cobaltiferous mispickel (danaite) from Sulitjelma were described by Professor A. W. Stelzner in 1891[2]: these were a centimetre in length, showed the forms {110}, {011}, {012}, and contained 6·81 per cent. of cobalt.

[1] Dr. Smythe remarks that in the method adopted in the second analysis there was a risk of insufficient washing, so that the lower figure for the iron is likely to be the more correct.

[2] A. W. Stelzner, 'Die Sulitjelma-Gruben im nördlichen Norwegen. Nach älteren Berichten und eigenen Beobachtungen besprochen,' Freiberg (Saxony), 1891. Stelzner's results are quoted by J. H. L. Vogt in Zeits. prakt. Geol., 1894, p. 43; and in Hintze's 'Handbuch d. Mineralogie,' 1901, vol. i, p. 863.

OBITUARIES.

Charles Alexander McMahon (1830–1904).

In Lieut.-General Charles Alexander McMahon, F.R.S., who died at his residence in Nevern Square, London, on February 21 last, our Society loses an earnest worker on the mineralogical side of geology. The son of Captain Alexander McMahon, of the East India Company's service, he was born at Highgate on March 23, 1830, and obtained his first commission, on February 4, 1847, in the 39th Madras Native Infantry, where he served for eight years. After this he became a member of the Madras Staff Corps, and was transferred to the Punjab Commission. Here he did admirable work for thirty years as Commissioner and Judge, gaining early a reputation for nerve and promptness in action. It was due to the latter that, at the outbreak of the Indian Mutiny—in May, 1857—just after he had taken charge of the Sialkot district, the revolted native troops were met and crushed by General Nicholson, then on the march to Delhi.

About the year 1871, McMahon, then Commissioner of Hissar, began to work at petrological questions, his first contribution, 'On the Blaine group and the central gneiss in the Simla Himalayas,' appearing in the 'Records of the Geological Survey of India' in 1877. In 1879, while on furlough in England, then a Lieutenant-Colonel, McMahon, with characteristic thoroughness, entered as a student at the Royal School of Mines, and attended the lectures by Professors Judd, Huxley, and Warington Smyth. The experience thus acquired was applied, on his return to India, to the thorough study of the crystalline rocks in the Himalayas, and he increased the two papers already published in the 'Survey Records' by nine others, in which he proved some gneisses to be igneous rocks, and their foliation due to movements prior to final consolidation.

After thirty-eight years' service he retired, but was promoted to Major-General in 1888 and Lieutenant-General in 1892, and he settled down in London to work steadily at his favourite studies, publishing papers in the 'Mineralogical Magazine,' the 'Geological Magazine,' the 'Proceedings of the Geologists' Association,' and the 'Quarterly Journal of the Geological Society.' The more notable in the last were on the crystalline rocks of the Lizard district, where his Indian experience stood him in good stead, and on the phenomena associated with the Dartmoor granites—though he did not lose touch with India, and

co-operated with his son, Major A. H. McMahon, in a valuable account of the geology of Gilgit.

Two or three of these papers were distinctly mineralogical, and, after joining our Society in 1882, he contributed four papers to this Magazine. The first, in volume viii, discusses the cause of a polysynthetic structure in some porphyritic quartz crystals from India; the second, in vol. ix, describes the bowenite or pseudo-jade from Afghanistan, which he shows to be a true serpentine of somewhat unusual hardness, its probable origin being a rather exceptional peridotite; the third, in vol. x, discusses the micro-chemical analysis of rock-making minerals, giving the results of his own experiences; and the fourth, also in that volume, deals with the optical characters of the globules and spherulites of lithium phosphate and some other salts.

He was a frequent attendant at scientific gatherings and an effective contributor to discussions, obtaining a reputation as a terse, clear speaker, who never rose unless he had something valuable to say. He became F.G.S. in 1878, served more than once on its Council, and received its Lyell Medal in 1899, was President of the Geologists' Association in 1894–5, and of the Geological Section of the British Association at Belfast in 1902, and was elected a Fellow of the Royal Society in 1898.

Between two and three years ago his eyesight began to fail, which obliged him to resign, in June, 1902, the Treasurership of this Society, to which he had been elected in the previous November; his general health then began to decline, and after several months' illness he died on February 21, 1904. But while the body was weak, the mind remained vigorous, for his last scientific writing, published in the 'Geological Magazine' for November, 1903, shows all his wonted grasp of his subject, and power of polished satire. One who has discussed with him, in the field and in the study, questions more or less controversial, may be allowed to add that as a worker none could be more thorough, cautious, and conscientious, while as a man he wore 'the white flower of a blameless life,' and combined unswerving rectitude of character with a remarkable gentleness of disposition.

T. G. Bonney.

Clement Le Neve Foster (1841–1904).

By the death of Sir Clement Le Neve Foster, mineralogical science has lost an enthusiastic cultivator, one who by precept and example ever

strove to promote the study of mineralogy, especially in its practical applications. He was the second son of the late Peter Le Neve Foster, for many years secretary of the Society of Arts, and was born at Camberwell on March 23, 1841. After early teaching at the Camberwell Collegiate School, he passed to a school at Boulogne, where at sixteen years of age he obtained his French degree of B.Sc., and then entered as a student at the Royal School of Mines. Here, in spite of youth, he succeeded, during his two years' career, in carrying off nearly all the prizes of the school, and when only nineteen years of age received an appointment on the Geological Survey. During his five years' work on the Survey, he accomplished, in conjunction with his colleague the late William Topley, a very brilliant piece of work, in the solution of the great problem of the denudation and drainage of the Weald.

In 1865, Le Neve Foster became lecturer to the Miners' Association of Cornwall and Devon, and in 1868 undertook exploring expeditions to Sinai and the Caratal gold-field in Venezuela; while from 1869 to 1872 he was resident engineer to some gold mines in Northern Italy.

Le Neve Foster again entered the Government service in 1872, being appointed H.M. Inspector of Mines in the district of Devon and Cornwall. He did much to introduce improved methods of working in the district, and by his efforts the lamentably high death-rate among the miners was greatly diminished; but in 1880 he was transferred to the North Wales district, of which he retained charge till his retirement in 1901.

It was during the period of Le Neve Foster's residence in Cornwall that this Society was founded, and he played an important part in its inauguration. Not only was he an original member and one of the first Council, but he became the first Foreign Secretary. The first volume of the 'Mineralogical Magazine' contains four papers from his pen—two on new minerals and mineral localities in Cornwall and Devon, and two dealing with methods of blowpipe analysis, a subject in which he always took the keenest interest and in which he was a recognized expert.

In later years, Le Neve Foster was so much occupied by his practical work in connexion with mining that he found little time for mineralogical research, though he retained a keen interest in the subject to the last.

At the time of his retirement from the Home Office, he had published twenty-nine annual official reports, which had an important influence in improving mining methods and ameliorating the conditions under which miners work. Until the time of his death he prepared for the Home Office a valuable yearly report on Mineral Statistics. He was also

author of several treatises on mining, which have taken the highest position among scientific manuals.

In 1890, Le Neve Foster succeeded Sir Warington Smyth as Professor of Mining in the Royal College of Science and Royal School of Mines, where the work that he did in improving methods of teaching and in influencing the careers of the students was of the highest importance.

In 1897, while in his official capacity investigating the cause of a great disaster at the Snaefell Mine in the Isle of Man, he nearly lost his life from carbon-monoxide poisoning. Although his life was saved, his health was so seriously impaired that he resigned his position in the Home Office in 1901, but he still continued his work in the School of Mines with some interruptions. On April 19, after a short illness from which he rallied several times, he at last succumbed to the effects of the sad Snaefell accident, passing away at the age of 63.

Le Neve Foster was a D.Sc. of London, and was elected a Fellow of the Royal Society in 1892. Last year he received, in recognition of his great public services, the honour of knighthood.

J. W. J.

Frank Rutley (1842–1904).

Frank Rutley was born at Dover on May 14, 1842. He received his early education at the Faversham Grammar School, and then went for some years to a private English school at Bonn. At an early age he displayed the artistic tastes and skill in draughtsmanship which often proved of such great service to him in his subsequent scientific career.

That at an early date he had acquired a taste for geological study is shown by the first scientific communication from his pen. A curious subsidence took place at Lexden in Essex in the year 1861, which was described in the 'Geological Magazine' for 1865 by the Rev. Osmond Fisher. In a letter to the editor of the Magazine, Rutley reproduces a section made by him after a visit to the locality in 1862, and proceeds to criticize Mr. Fisher's theory for explaining the phenomenon. With characteristic modesty, Rutley writes that he questions Mr. Fisher's explanation 'with all humility, as I am but a very young hand at geology.'

It was in 1862 that Rutley entered the School of Mines, then at Jermyn Street, and he attended the lectures of Hofmann, Tyndall, Huxley, Ramsay, and Warington Smyth in the various branches of science taught there, though he did not complete the associateship course by devoting himself to technical work in mining or metallurgy.

On leaving the School of Mines in 1864, Rutley joined the army and became an Ensign in the First Royal Scots regiment. But in 1867 he resigned his commission to take up an appointment as temporary Assistant Geologist upon the Geological Survey of England and Wales. The country he was sent to survey was a portion of the Lake District, where his old college companion Clifton Ward was already at work. In 1870 and 1871 Rutley wrote letters to the 'Geological Magazine' upon the subject of the glaciation of the Lake District, in which he displayed a minute knowledge of the geology of the area, in his criticism of the views of the late Mr. Mackintosh.

It was at this time that Rutley first showed his skill as a worker with the microscope, in the study of minerals and rocks—a branch of geological inquiry which had only recently been inaugurated by the labours of Sorby, David Forbes, Allport, and a few other workers in this country. This led to his being transferred to the central office of the Geological Survey at Jermyn Street, where he not only arranged a very instructive series of specimens for the Museum of Practical Geology, but also aided the surveyors in the field by his examination and description of rock-specimens sent up to town by them. To this period belong the important memoirs which he wrote for the Geological Survey upon 'The felsitic lavas of England and Wales' and 'The volcano of Brent Tor.'

As early as the year 1879, Rutley wrote a book, 'The Study of Rocks,' which was the first work of the kind in the English language, wherein an attempt was made to systematize the rapidly growing knowledge obtained by the microscopic study of rock-sections. In 1888, a more detailed text-book for students on 'Rock-forming Minerals' was the outcome of his experience as a teacher; while in 1895 he issued his 'Granites and Greenstones: a series of tables and notes for students of petrology.' Rutley also wrote a very compact and compendious manual of 'Mineralogy,' which passed through a number of editions.

In 1882, Rutley was appointed lecturer on mineralogy in the Geological Division of the Royal College of Science, with which the School of Mines had then been incorporated. He devoted himself with the most painstaking care to the instruction of the students, his patience and skill in illustration being always conspicuous. At the same time he was still carrying on work for the Geological Survey, and enriching geological literature by many valuable researches. In the 'Quarterly Journal of the Geological Society' twenty-six papers from his pen attest his constant activity. They include his valuable memoirs on the rocks of the Malvern Hills, upon the structures displayed by various glassy rocks, both fresh

and devitrified, upon novaculites and quartzites, on the 'porfido rosso antico,' and on the dwindling of limestones. To the Royal Society he contributed two papers, one, in conjunction with Mr. Herman, 'On the microscopic characters of some specimens of devitrified glass, with notes on certain analogous structures in rocks'; the other, 'Notes on alteration induced by heat in certain vitreous rocks.' He also wrote papers for the 'Geological Magazine,' the Royal Microscopical Society, and the Geological Societies of Ireland and Cornwall.

Rutley joined the Geological Society in 1870, and in 1881 the balance of the proceeds of the Murchison Fund was awarded to him by the Council of the Society in recognition of his work and to assist him in his researches. He joined the Mineralogical Society in 1888, and served upon the Council from 1890–3, and in 1897–8. He wrote a paper on the classification and nomenclature of crystallites in the 'Mineralogical Magazine,' vol. ix, and several papers on quartz, zircon, manganite, and on fulgurites, &c., in vol. x of the Magazine. He was also a member of the French Mineralogical Society.

In 1898, Rutley's scientific activities and his work as a teacher were alike interrupted by a stroke of paralysis, and though he still continued to do a little work, his friends from that time missed his familiar presence at scientific gatherings. He passed away peacefully on May 16, 1904, after a long and patiently borne illness, and was buried in the Fulham Cemetery. Many friends mourn the loss of a true-hearted colleague and fellow-worker, and will long cherish a memory of the man and of the excellent work that he accomplished.

J. W. J.

Henry Palin Gurney (1847–1904).

Henry Palin Gurney, eldest son of Henry Gurney and Eleanor Palin, was born in London on September 7, 1847. He received his early education at the City of London School, proceeding afterwards to Clare College, Cambridge. There he distinguished himself both in Athletics and the Schools: he rowed in the college boat and ran for his University in the Oxford and Cambridge Sports of 1868 and 1869; he took both the Mathematical and Natural Sciences Triposes in the year 1870, being placed fourteenth wrangler in the former and in the first class in the latter; immediately afterwards he was elected to a college fellowship, which he held till 1883. In 1871 Mr. Gurney took orders in the Church of England, and for the next four years worked as curate to Canon Beck in one of the largest and poorest of London parishes, that of Rother-

hithe; in the early part of that period he was married at Whitchurch in Herefordshire to Louisa, daughter of the Rev. H. Selby Hele, of Grays, Essex, and great-granddaughter of Bishop Horne.

Mr. Gurney's innate love of crystals had been developed under the influence of the Cambridge Professor, William Hallows Miller, during whose illness he later acted for some time as Deputy. Appreciating the difficulties which at that epoch presented themselves to English students, Mr. Gurney wrote a very simple and useful Manual of Crystallography (128 pages), founded on the Tract of Professor Miller and the Lectures of Professor Story-Maskelyne; it was published in 1875 by the Society for Promoting Christian Knowledge. He was one of the Original Members of the Crystallological Society founded on June 14, 1876, and was a Member of its first Council. At one time he meditated acceptance of an appointment in the Mineral Department of the British Museum, but, notwithstanding the great attractions which work in a mineral collection would have had for him, he did not feel justified, having regard to the interests of his family, in becoming a candidate for a post of which the prospective emoluments must be both uncertain and small.

Instead, therefore, of making research in mineralogy and crystallography his life-work, Mr. Gurney accepted an offer made to him and became a colleague, afterwards (1877–94) managing partner, of Mr. Walter Wren in the large establishment which the latter had instituted at Westbourne Park for the training of candidates for the various competitive examinations for posts in the Army and in the Home and Indian Civil Services; there his vast energy, physical and mental, found full employment. His remarkable powers of organization, and the personal influence he was able to bring to bear on young men of ability at a very critical period of their lives, contributed largely to the success of the undertaking. The pupils of that establishment now occupy prominent posts in every part of Greater Britain, and it thus comes about that few tutors have ever been more widely known and respected. During a large part (1876–88) of this period, he officiated as curate of the church of St. Peter in Bayswater.

When the Principalship of the Durham College of Science, Newcastle-upon-Tyne, fell vacant through the resignation of Dr. William Garnett, it was felt that the educational experience, the wide culture and attainments, and the personal character of Mr. Gurney marked him out as the ideal man for that important position. His appointment to the post has been abundantly justified during the ten years which have since elapsed.

He devoted himself to the advancement of the interests of the college

in every possible way. Of the thousands of students who have passed through the institution during his tenure of office, many will long remember his kindly advice and ready help. His charm of manner and sweetness of disposition made him everywhere popular; and at distributions of school-prizes and public meetings in general in Newcastle and the surrounding district, he was sure of a hearty welcome. He took a leading part in inducing the promoters of the Armstrong Memorial Fund to devote its proceeds to the completion of the college buildings, and he afterwards gave help in the encouragement of subscriptions. Mr. Gurney provided a remarkable illustration of the well-known fact that the busiest man is the one who is most ready to add to his work and responsibilities: he was the representative of the college on the governing bodies of schools at Newcastle, Rothbury, Hartlepool, and Middlesbrough; he was a co-opted member of both the Newcastle and Northumberland Education Committees; he was Chaplain to the Bishop of Newcastle, and also to the Third Volunteer Battalion of the Northumberland Fusiliers; he was Warden of the Newcastle Diocesan House of Mercy.

Notwithstanding the great multiplicity of the duties which fell to him as Principal, and the demands made on his time by the professorship of mathematics which he later combined therewith, Mr. Gurney found it possible to give some attention to the development of his old subject, the study of crystals. Impressed with the importance of crystallography both as an independent science and as auxiliary to chemistry, physics, mineralogy, and petrology, he equipped the college with apparatus for the measurement of the angles and for the determination of the symmetry and optical characters of crystals, and arranged that opportunity for the acquisition of a theoretical and practical knowledge of the science should be provided for Newcastle students.

Mr. Gurney received the honorary degree of D.C.L. from the University of Durham; he was a Fellow of the Geological and Physical Societies, and for several years was a Member of the Council of the Mineralogical Society.

Whenever it was practicable for him, Mr. Gurney sought complete relaxation and change of thought in travel, spending many of his vacations abroad and availing himself of every opportunity of visiting places of general or geological interest both in Europe and America. With the present writer he spent several happy holidays; on one occasion journeying to Moscow, Nijni Novgorod, and down the Volga to Kazan afterwards making an excursion with other members of the International

Geological Congress to various noteworthy places in Finland: a brief account of the latter he gave in his 'Notes on the Geology of Finland.' He was an ideal companion; full of energy and enthusiasm; of infinite patience, good temper, and cheerfulness; indeed, to see his pleasant face and hear his hearty laugh was almost a holiday in itself. Only a few short weeks ago he proposed that they should again spend a few weeks together, this time at Arolla in Switzerland, where he was to go with two of his daughters, but the writer was unable to leave London. Soon afterwards came the startling news of his death. With only a walking-stick in his hand, he had started off alone at 8 a.m. on August 13, not saying, probably not knowing, how far he was likely to go. Night came and he did not return. Search was immediately begun, and by dusk the next day his footmarks had been discovered on an *arête* of the Gysa, a southern spur of Mount Roussette; there they ceased. Soon after dawn on the following morning his body was discovered several hundred feet below; his watch had stopped at nearly twelve. Notwithstanding the caution and carefulness which were ever prominent features in his own character, and were strongly impressed by him on others, he had doubtless been gradually led on by the beauty of the view to climb higher and higher, and had eventually and unexpectedly found himself in a place where a slip was easy and would mean instant death.

His loss will long be felt far and wide, more especially in the North of England, where he had lived for the last ten years; but for the members of his family and his intimate friends, more especially for one to whom he always showed the kind feeling of a brother, it will cast a shadow over what remains of life. L. Fletcher.

Ferdinand André Fouqué (1828–1904).

By the death of Professor Fouqué, on March 7, our Society loses a distinguished Honorary Member, elected in 1898. Since 1877 he had been Professor of Natural History in the Collège de France, and in 1881 was elected Membre de l'Institut. His first paper, with St. Claire Deville in 1854, dealt with the losses experienced by minerals when heated, and his studies in volcanic geology led to the publication, in 1879, of his great work 'Santorin et ses éruptions.' In conjunction with Michel Lévy he published two other important monographs—'Minéralogie micrographique: roches éruptives françaises' (1879), and 'Synthèse des minéraux et des roches' (1882)—and he was the author, often also in collaboration with Michel Lévy, of numerous papers on petrology and on rock-forming minerals.

Edward John Chapman (1821–1904).

Born in London on February 22, 1821, Dr. Chapman was educated in France and Germany, and after acting as Professor of Mineralogy in University College, London, was for many years (1853–1895) Professor of Mineralogy and Geology in University College, Toronto. He died at Hampton Wick, near London, on January 28, 1904. In 1843, he published a 'Practical mineralogy,' and a posthumous work bears the title 'Mineral systems, a review: with outline of an attempted classification of minerals in natural groups.' He was also the author of several other separately-published works, including a volume of poems. Many of his earlier mineralogical papers, on blowpipe analysis, classification of minerals, &c., appeared in the 'Philosophical Magazine,' while later papers, on the mineralogy and geology of Canada, appeared in Canadian journals.

Charles Soret (1854–1904).

Charles Soret, formerly Professor of Mineralogy and afterwards of Physics, and also for a time Rector of the University of Geneva, died at Geneva on April 4. He was the son of Jacques Louis Soret, also Professor of Physics at Geneva. His published papers treat of the optical and thermal properties of crystals, and he was the author of 'Éléments de cristallographie physique' (1893).

Sándor Schmidt (1855–1904).

From 1876 until 1895 Alexander Schmidt was an assistant in the mineralogical division of the Hungarian National Museum, during which time he obtained special permission to study for two years (1882–3) at Strassburg under Professor Groth. Previous to his appointment in 1895 as Ordinary Professor of Mineralogy and Geology in the Polytechnic at Budapest, he was Extraordinary Professor of Mineralogy in the University. His several papers are mainly descriptive of Hungarian minerals. He was born at Szegedin, Comitat Csongrád, Hungary, in 1855, and died at Budapest on May 16, 1904.

Édouard Cumenge (1828–1902).

Cumenge's career as a mining expert commenced with his appointment in the French Corps des Mines, but after 1852 his position was only honorary (Ingénieur en chef honoraire des Mines). With C. Friedel and Mallard he described guejarite, boleite, and carnotite as new species, and the mineral cumengeite was named after him.

NOTES.

Testimonial to Professor Groth.—Two years ago, when the 'Zeitschrift für Krystallographie und Mineralogie,' founded in 1877 by Professor Paul Groth, completed the twenty-fifth year of publication, various mineralogists in different countries felt that such an epoch provided a fitting opportunity for commemorating the invaluable services which Professor Groth has rendered to mineralogy and crystallography by his initiation and continuous editorship of that journal, which now extends to thirty-nine volumes. Accordingly, Professor M. H. N. Story-Maskelyne, Professor W. J. Lewis, Mr. L. Fletcher, and Professor H. A. Miers, formed themselves into a Committee, and charged themselves with the pleasant task of bringing the well-wishers of Professor Groth in different parts of the world into touch with each other. The letter, sent out by the secretaries on December 6, 1902, met with a hearty response, and a sufficient sum of money was obtained to enable the Committee to commission Professor Eduard Grützner, of Munich, to paint a portrait of Professor Groth. The picture, together with the following letter from Professor M. H. N. Story-Maskelyne, the Chairman of the London Committee, was formally presented to Professor Groth at Munich on April 30, 1904.

An excellent photogravure (measuring $12 \times 15\frac{1}{2}$ inches) of the portrait, reproduced by Dr. E. Albert & Co., of Munich, has been sent to each of the 273 individual subscribers to the fund.

The Athenaeum, Pall Mall, London, S.W.
April 28, 1904.

My dear Colleague,

The correspondence which has passed between our friend Mr. Fletcher, of the British Museum, and yourself, and has resulted in the successful completion of your portrait by the distinguished artist Professor Grützner, will find its appropriate sequel in this letter.

It is accordingly my most welcome duty, as representing the London Committee that initiated our proceedings, to ask your acceptance of the portrait, which I hereby present to you in the name of many friends in many lands: some personally known to you, others without that privilege, but all wishing to manifest to you their grateful acknowledgement of the services rendered to Science by your enlightened initiation and laborious editorship through a quarter of a century of the 'Zeitschrift für Krystallographie und Mineralogie,' a continuous record of nearly everything that has been done in those sciences since the year 1877, and an emporium of theory and of fact absolutely necessary for all who would pursue successful study and research in them.

While conveying to you this expression of our profound appreciation, which

I do on behalf of the numerous contributors named in the accompanying list, I have an especial pleasure in being able to subscribe myself,

My dear friend and colleague,
as most truly yours,
NEVIL STORY-MASKELYNE.

Professor Paul Groth, Munich.

In acknowledgement of the above letter, Professor Groth wrote as follows:—

München, den 30. April 1904.

Herrn Professor M. H. N. Story-Maskelyne.

HOCHVEREHRTER HERR KOLLEGE!

Mit dem aufrichtigsten Danke für Ihr so überaus liebenswürdiges Schreiben zeige ich Ihnen an, dass das schöne und wertvolle Gemälde, welches Herr Professor E. Grützner auf Wunsch des aus Ihnen, dem allverehrten Nestor unserer Wissenschaft, und unseren Freunden W. J. Lewis, L. Fletcher und H. A. Miers bestehenden Comités ausgeführt hat, mir nunmehr durch die freundliche Vermittelung des Herrn Professor K. Oebbeke, als hiesigen Vertreter des Comités, übergeben worden ist.

Als Herr Kollege L. Fletcher mir die erste Mitteilung von der mir zugedachten Ehrung machte, waren die Vorbereitungen dazu schon so weit gediehen, dass ich sie akzeptieren musste, obgleich ich mir recht wohl bewusst war, wie weit dieselbe über mein Verdienst hinausgehe. Aus der mir von Ihnen gütigst übersandten Liste der Teilnehmer ersehe ich nun, dass nicht nur die Träger so vieler mir lieber und wohlbekannter Namen von Freunden und Schülern, sondern auch zahlreiche, mir persönlich nicht bekannte Fachgenossen in England und in fast allen andern ausserdeutschen Kulturländern zu dieser Ehrung beigetragen haben. In erster Linie ist dies das Verdienst der Korrespondenten des Comités für die verschiedenen Länder, der Herren H. Bäckström für Schweden, H. Baumhauer für die Schweiz, F. Becke für Österreich, W. C. Brögger für Norwegen, S. Calderón für Spanien, G. Cesàro für Belgien, F. W. Clarke für die Vereinigten Staaten, B. J. Harrington für Canada, F. J. Loewinson-Lessing und P. Zemjatschensky für Russland, R. Panebianco für Italien, N. V. Ussing für Dänemark, G. Wyrouboff für Frankreich.

Wenn es für mich auch fast beschämend ist, dass so viele ausgezeichnete Forscher es nicht verschmäht haben, für diesen Zweck Zeit und Mühe zu opfern, so ist es mir doch andererseits eine grosse Freude und Genugtuung, hieraus zu ersehen, dass die bescheidenen Dienste, welche ich der Wissenschaft durch die Gründung und Leitung der 'Zeitschrift' geleistet habe, eine so allgemeine und freudige Anerkennung gefunden haben.

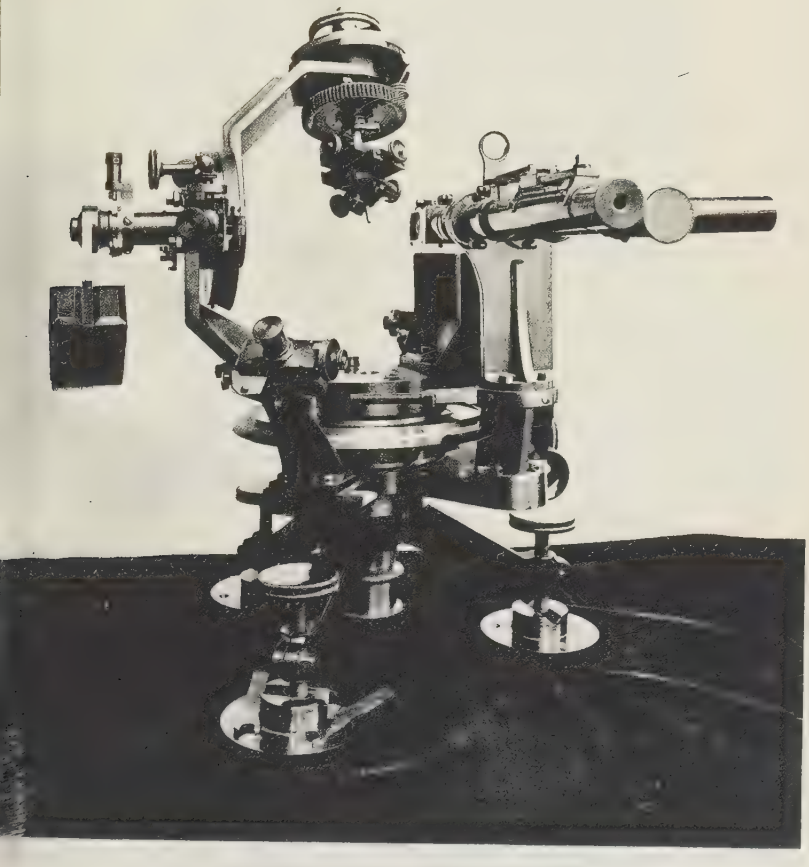
Lassen Sie mich deshalb Ihnen, den Herren Comité-Mitgliedern und Korrespondenten und sämtlichen Teilnehmern meinen allerherzlichsten Dank aussprechen für die Ehrung, welche sie mir durch die Darbringung eines Geschenkes erwiesen haben, dessen Anblick mir bis zu meinem Lebensende die Erinnerung an die mir dadurch bezeugte freundliche Gesinnung aller Teilnehmer wacherhalten wird.

Indem ich diesem Dank noch die Versicherung meiner ausgezeichneten Hochachtung für Sie hinzufüge, verbleibe ich

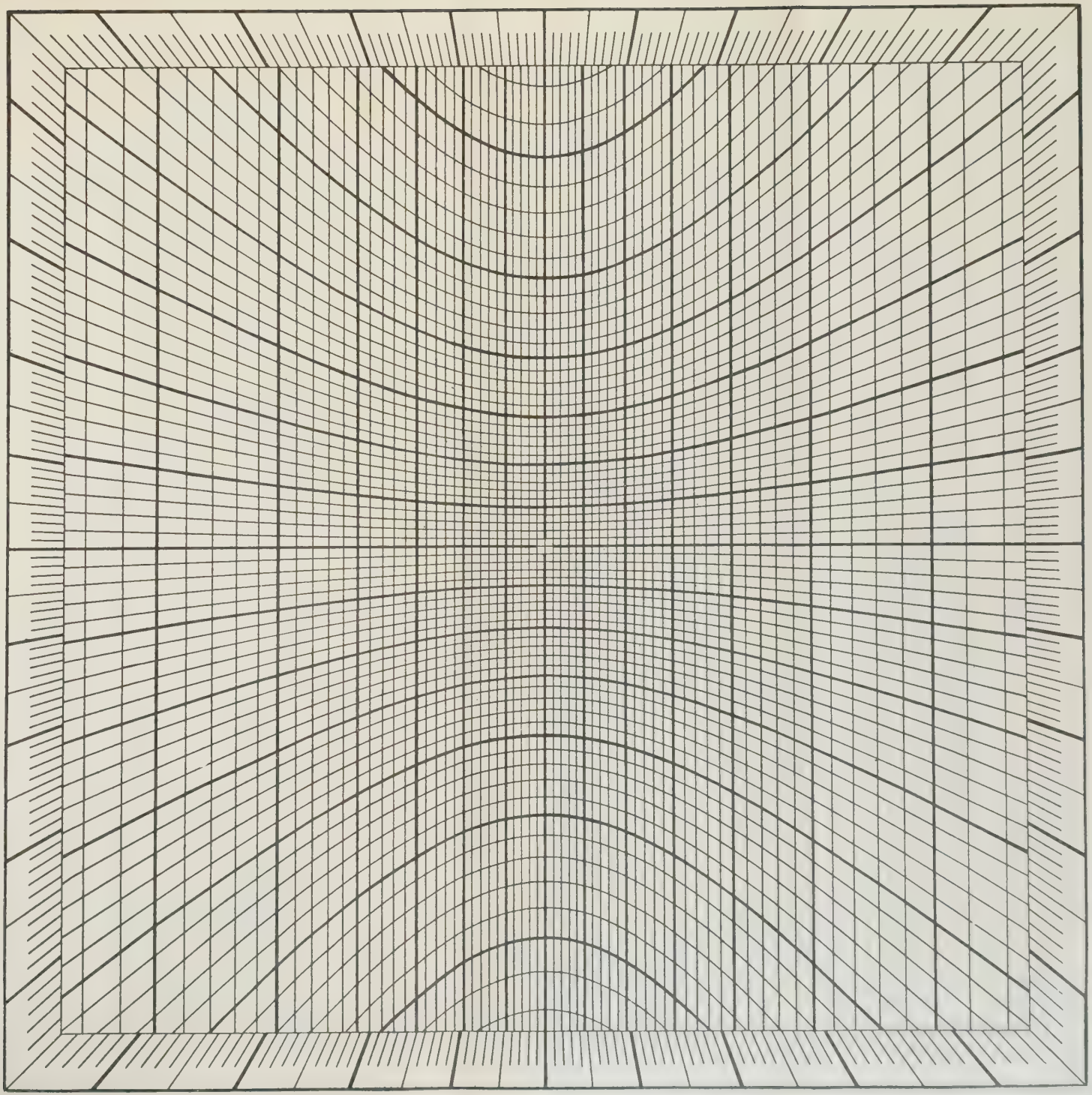
Ihr treu und dankbar ergebener
P. GROTH.

To the memory of Professor Antonio D'Achiardi (1839–1902) there has been issued a volume representing the work done, during the year 1903, in the Mineralogical Laboratory of the University of Pisa. The volume (Pisa, 1903, 173 pp. and 6 plates) consists of a collection of eleven mineralogical and petrographical papers, by Professor Giovanni D'Achiardi (his father's successor at Pisa), Dr. Ernesto Manasse, and Dr. Piero Aloisi, which have already appeared in the 'Atti della Società Toscana di Scienze Naturali.' Earlier in the same year there was also published a report of the commemoration service, together with a portrait, biographical notice, and list of papers of the late professor.

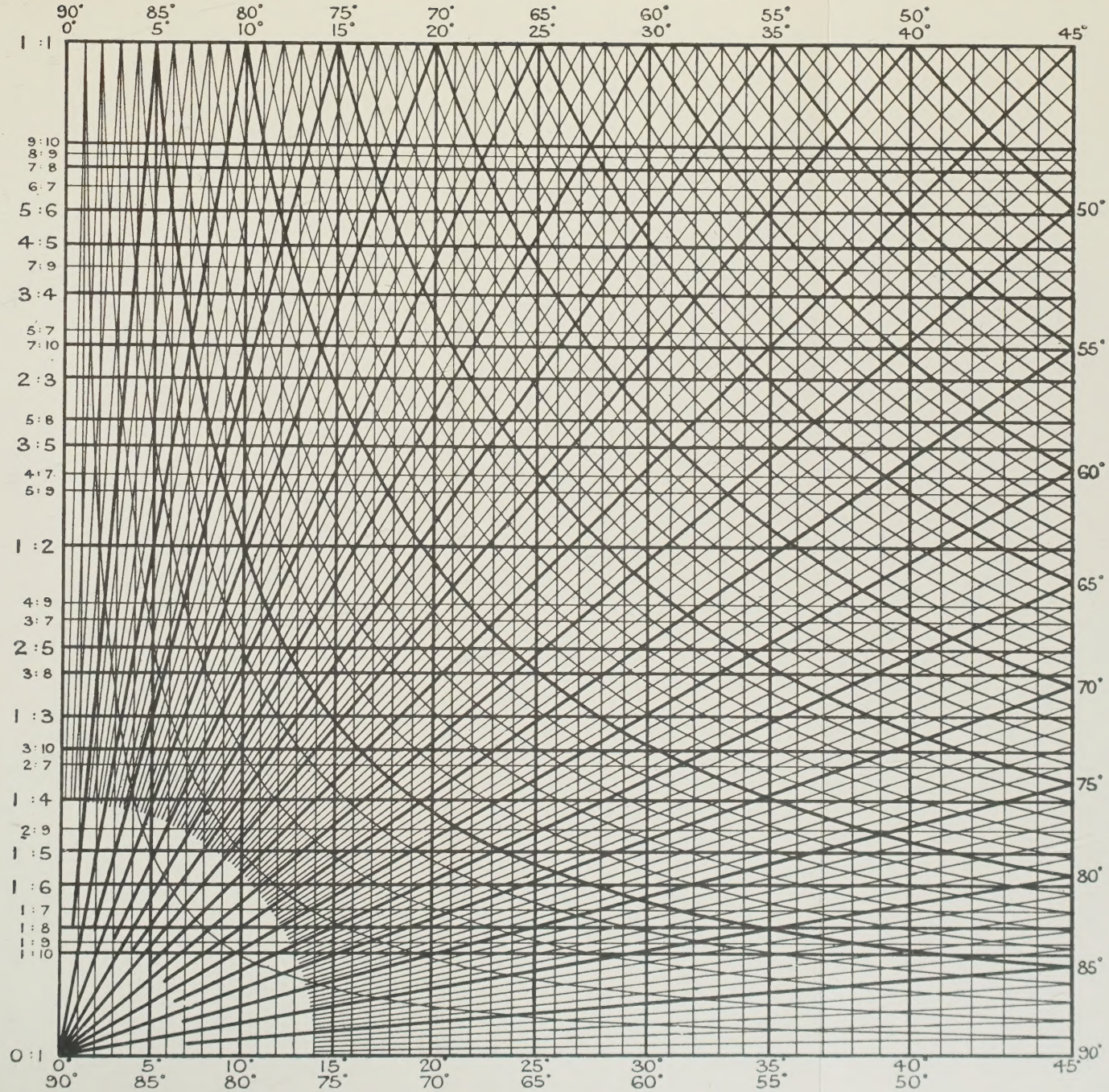
An instance of the inconsistencies which may readily arise in the statement of mineral localities is noted by Professor V. Goldschmidt (Zeits. Kryst. Min., 1903, vol. xxxviii, p. 498). The locality of certain highly modified crystals of pyrites from Hungary has been variously stated as: (1) Porkura in the Csetrás mountains, (2) Csetrás, (3) Kis-Almás. These all refer to the same spot, which is situated in the valley of the Szlatyin brook near to the villages of Porkura and Kis-Almás (but within the boundaries of the latter) in Comitat Hunyad, Transylvania.



G. F. HERBERT SMITH: THREE-CIRCLE GONIOMETER.



Harold Hilton: The Gnomonic Net.



G. F. HERBERT SMITH: THE MORIOGRAM.

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